JUL 3 1986

536

Y4.Sci2:99/88

FISCAL YEAR 1987 DEPARTMENT OF ENERGY AUTHORIZATION

(Fossil Energy)

190

ORIGINAL

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

SECOND SESSION

MARCH 4, 1986

[No. 88]

VOLUME II

Printed for the use of the
Committee on Science and Technology

FISCAL YEAR 1987 DEPARTMENT OF ENERGY AUTHORIZATION
(Fossil Energy)

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

SECOND SESSION

MARCH 4, 1986

[No. 88]

VOLUME II

Printed for the use of the
Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE
59-544 O WASHINGTON : 1986

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

I

COMMITTEE ON SCIENCE AND TECHNOLOGY

DON FUQUA, Florida, *Chairman*

ROBERT A. ROE, New Jersey
GEORGE E. BROWN, Jr., California
JAMES H. SCHEUER, New York
MARILYN LLOYD, Tennessee
TIMOTHY E. WIRTH, Colorado
DOUG WALGREN, Pennsylvania
DAN GLICKMAN, Kansas
ROBERT A. YOUNG, Missouri
HAROLD L. VOLKMER, Missouri
BILL NELSON, Florida
STAN LUNDINE, New York
RALPH M. HALL, Texas
DAVE McCURDY, Oklahoma
NORMAN Y. MINETA, California
MICHAEL A. ANDREWS, Texas
BUDDY MacKAY, Florida **
TIM VALENTINE, North Carolina
HARRY M. REID, Nevada
ROBERT G. TORRICELLI, New Jersey
RICK BOUCHER, Virginia
TERRY BRUCE, Illinois
RICHARD H. STALLINGS, Idaho
BART GORDON, Tennessee
JAMES A. TRAFICANT, Jr., Ohio

MANUEL LUJAN, Jr., New Mexico *
ROBERT S. WALKER, Pennsylvania
F. JAMES SENSENBRENNER, Jr., Wisconsin
CLAUDINE SCHNEIDER, Rhode Island
SHERWOOD L. BOEHLERT, New York
TOM LEWIS, Florida
DON RITTER, Pennsylvania
SID W. MORRISON, Washington
RON PACKARD, California
JAN MEYERS, Kansas
ROBERT C. SMITH, New Hampshire
PAUL B. HENRY, Michigan
HARRIS W. FAWELL, Illinois
WILLIAM W. COBEY, Jr., North Carolina
JOE BARTON, Texas
D. FRENCH SLAUGHTER, Jr., Virginia
DAVID S. MONSON, Utah

Harold P. Hanson, *Executive Director*
Robert C. Ketcham, *General Counsel*
Regina A. Davis, *Chief Clerk*
Joyce Gross Freiwald, *Republican Staff Director*

Subcommittee on Energy Development and Applications

DON FUQUA, Florida, *Chairman*

ROBERT A. ROE, New Jersey
RALPH M. HALL, Texas
RICK BOUCHER, Virginia
TERRY BRUCE, Illinois
JAMES A. TRAFICANT, Jr., Ohio
DOUG WALGREN, Pennsylvania
ROBERT A. YOUNG, Missouri
DAVE McCURDY, Oklahoma
RICHARD H. STALLINGS, Idaho

F. JAMES SENSENBRENNER, Jr., Wisconsin
CLAUDINE SCHNEIDER, Rhode Island
RON PACKARD, California
HARRIS W. FAWELL, Illinois
WILLIAM W. COBEY, Jr., North Carolina
JOE BARTON, Texas
D. FRENCH SLAUGHTER, Jr., Virginia

William T. Harvey, *Staff Director*
Harlan L. Watson, *Science Consultant*
R. Thomas Weimer, *Republican Energy Coordinator*
David J. Beightol, *Republican Technical Consultant*

---

*Ranking Republican Member.
**Serving on Committee on the Budget for 99th Congress.

CONTENTS

WITNESSES

Page

Donald L. Bauer, Acting Assistant Secretary for Fossil Energy, U.S. Department of Energy, accompanied by Mr. Jeremiah E. Walsh, Jr., Deputy Assistant Secretary for Management, Planning and Technical Coordination, Mr. Richard E. Harrington, Deputy Assistant Secretary for Coal Utilization, Advanced Conversion and Gasification, and Mr. Keith N. Frye, Deputy Assistant Secretary for Oil, Gas, Shale, and Coal Liquids 6
Prepared statement 9
Discussion 38
Questions and answers for the record 55

PANEL 1

David G. Webb, senior vice president for the policy and regulatory affairs, Gas Research Institute 74
Prepared statement 78
George H. Lawrence, president, American Gas Association 93
Prepared statement 95
Dr. Bernard S. Lee, president, Institute of Gas Technology 113
Prepared statement 116
Panel 1 discussion 129
Questions and answers for the record:
Mr. Webb 139
Mr. Lawrence 141
Dr. Lee 142

PANEL 2

Dr. Gene G. Mannella, director, Washington office, Electric Power Research Institute 144
Prepared statement 147
Dr. George F. Mechlin, vice president for research and development, Westinghouse Electric Corp 177
Prepared statement 181
Mr. Michael S. Koleda, president, Council on Synthetic Fuels 192
Prepared statement 196
Panel 2 discussion 201
Questions and answers for the record:
Mr. Mannella 205
Dr. Mechlin 214
Mr. Koleda 216

PANEL 3

Dr. J. Read Holland, director, School of Mines and Energy Development, University of Alabama 218
Prepared statement 222
Dr. Charles J. Mankin, State geologist, State of Oklahoma 226
Prepared statement 233
Mr. Dave Brown, president, MHD Industrial Forum 266
Prepared statement 268
Panel 3 discussion 272

Questions and answers for the record:

Page
- Dr. Holland ... 274
- Dr. Mankin ... 278
- Mr. Brown ... 280

Additional statements for the record:

- Letter from Jeffrey A. Serfass, executive director, Fuel Cells User Group, March 14, 1986; accompanied by statement on Fuel Cell Research, Development and Commercialization and the Federal Budget for Phosphoric Acid Fuel Cell Technology, by Stephen A. Mallard on behalf of Fuel Cells Users Group ... 285
- Letter from Alex G. Oblad, et al., Department of Fuels Engineering, University of Utah (February 28, 1986) as updated March 5 ... 293
- Letter from George C. Pimentel, president, American Chemical Society, March 7, 1986 ... 296
- Statement for the record from Frank C. Schora, president, HYCRUDE Corp., March 4, 1986 ... 301
- Statement for the record from Walter R. Hibbard, Jr., Virginia Polytechnic Institute and State University, March 4, 1986 ... 309
- Statement for the record from Dr. George W. Roberts, Air Products and Chemicals, Inc., March 4, 1986 ... 312
- Statement for the record from Dr. Y.C.L. (Susan) Wu, University of Tennessee Space Institute, March 4, 1986 ... 316
- Statement for the record from Joseph A. McElwain, chairman of the board, MHD Development Corp., Butte, MT ... 323
- Statement for the record from Jack Sherrick, president and general manager, MSE, Inc ... 326
- Statement for the record from Donald R. Glenn, Energy Research Corp ... 329
- Statement for the record from William Podolny, International Fuel Cells Corp., March 4, 1986 ... 338
- Letter and statement for the record from Lyle V.A. Sendlein, Institute for Mining and Minerals Research, University of Kentucky, March 3, 1986 ... 342
- Statement for the record from Dr. C. Everett Brett, director, Natural Resources Center, School of Mines and Energy Development, University of Alabama ... 346

APPENDIX

ADDITIONAL MATERIALS FOR THE RECORD

- Department of Energy Fiscal Year 1987 Congressional Budget Request, Fossil Energy Research and Development, volume 6, Clean Coal Technology ... 351
- Department of Energy Fiscal Year 1987 Congressional Budget Request, Fossil Energy Research and Development, volume 6 ... 357
  - Appropriation language ... 358
  - Amounts available for obligation ... 359
  - Summary of estimates by major category ... 360
  - Program overview ... 361
  - Coal:
    - Control technology and coal preparation ... 367
    - Advanced research and technology development ... 378
    - Coal liquefaction ... 390
    - Combustion systems ... 399
    - Fuel cells ... 406
    - Heat engines and heat recovery ... 412
    - Underground coal gasification ... 416
    - Magnetohydrodynamics ... 421
    - Surface coal gasification ... 424
  - Petroleum:
    - Advanced process technology ... 433
    - Enhanced oil recovery ... 439
    - Oil shale ... 447
  - Gas—unconventional gas recovery ... 453
  - Policy and management ... 460
  - Cooperative R&D venture pools ... 469
- Report on the Wilsonville Advanced Coal Liquefaction R&D Facility, January 29, 1986, transmitted by Donald L. Bauer, Acting Assistant Secretary for Fossil Energy ... 473

1987 DEPARTMENT OF ENERGY AUTHORIZATION

TUESDAY, MARCH 4, 1986

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Development and Applications,
Washington, DC.

The subcommittee met, pursuant to call, at 9:30 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Mr. Fuqua. The subcommittee will be in order.

Today we continue the EDA Subcommittee hearings on the Department of Energy's fiscal year 1987 authorization request. We have witnesses today from DOE as well as other organizations that are interested in the fossil fuel budget.

We note first of all that the request is a reduction of over 50 percent from the 1986 appropriation level. We see next that nearly half of the proposed program activity will be funded by deferrals from prior year balances. Specifically, DOE has asked the Appropriations Committee to defer $67 million of fossil energy programs from fiscal year 1986 to fiscal year 1987. They request a congressional response by March 20, which seems to be a rather short period of time, since the evaluation of the proposed 1987 request is part of the process.

DOE has acted among some contractors as though the deferrals will be acceptable, and they failed to negotiate some contracts and have canceled some others. So, today we hope to review this situation.

This substantial reduction in annual funding raises a point that long-term program objectives and goals cannot possibly be maintained and met. This could mean that in some cases serious injury is done to programs and to our ability to continue them to logical conclusions. Thus, we are not only spending fewer dollars in the future but we, in effect, waste money spent in the past. We also question the Department's long-term fiscal objectives. If similar program reductions can be expected to meet lower deficit ceilings in subsequent years, it won't take long to eliminate all the programs totally.

There is that possibility, that under the Hollings-Rudman-Gramm Act, we might see reductions in all programs at less stringent levels than is proposed for the fossil energy program. For instance, if all nonexempt program activities and projects shared equally to meet the $144 billion deficit ceiling, we might see a reduction from the fiscal year 1986 level on the order of 15 percent. It was mentioned during the hearing with Secretary Herrington that DOE plans to defer certain fiscal year 1986 program plans. That may be premature, because subsequent fiscal year 1987 action might not curtail fossil energy programs to the extent requested by the authorization material.

Although there is little mention of the clean coal technology initiative in the fiscal year 1987 authorization request, it seems proper to mention that activity at this time. We are gratified to note the Secretary's modification of the program opportunity notice. Payback of the Federal participation in a specific program now occurs after the contract period of performance and then only from profits rather than from revenues. Surely, this will find a larger number of meaningful, exciting proposals under the circumstances than under the previous ones required by DOE.

We look forward to hearing from our outside witnesses who were asked to comment on budget levels at the reduction of 15 percent from the fiscal year 1986 appropriation levels. Their suggestions and recommendations will be very beneficial to our subcommittee as it tries to establish an alternative to the fiscal year 1987 fossil energy budget.

Mr. Sensenbrenner.

Mr. SENSENBRENNER. Thank you, Mr. Chairman.

This is not the first DOE budget request that has had a severe drop in authorized funding for fossil energy activities. However, I am concerned that the 73-percent decrease in new budget authority for fiscal year 1987 might be much too disruptive to continue going on doing the business that is necessary in making fossil fuel burn cleaner and become more efficient. So, the burden of proof, in my opinion, is on the administration, on justifying this large a decrease when a lot of the other programs are not being significantly decreased altogether.

Now, unlike many of my brethren on the majority side of this subcommittee, I recognize that the Gramm-Rudman-Hollings Act does require us to meet some targets. So, it seems to me that those who wish to see increases in budget authority in this particular area are going to have to support dollar-for-dollar decreases elsewhere. This is going to mean somewhat of a reordering of priorities. Some people who think that they are getting along quite well might be in for a rude awakening. But I certainly hope that, when the subcommittee does mark up the DOE authorization bill for fiscal year 1987, rather than doing what we did in the past and adding on to fossil energy, we will figure out some way to take it off elsewhere.

Mr. FUQUA. Without objection, the statements of Mr. Hall and Mr. McCurdy will be inserted into the record.

[The prepared opening statements of Mr. Hall and Mr. McCurdy follow:]

Statement by
Congressman Ralph M. Hall
Energy Development and Applications Subcommittee
March 4, 1986

Mr. Chairman and Members of the Committee --

I want to thank the Chairman for recognizing me at this time. I regret being unable to be here for the earlier testimony due to scheduling conflicts, because I believe the DOE Fossil Energy Research and Development effort is particularly important to the long term health and viability of the domestic oil and gas industry and for national security.

Mr. Chairman, the Committee has reached a crucial point in its continuing review and evaluation of the Fossil Energy R&D budget, and I think it is particularly important to review the Department's FY 87 request in light of the substantial restructuring that is taking place in the domestic oil and gas industry today.

In a nutshell, what is happening is that the major oil and gas producers are selling, or would like to sell, substantial portions of their domestic, onshore reserves so that they may concentrate their efforts in the offshore areas and overseas. The reason this is occurring is that it has become less profitable to operate these properties as production has declined. However, it is important to remember that, in most cases, over 50 percent of the original oil in place is still in the ground. It is going to require some clever enhanced recovery techniques, not yet developed, to produce a substantial portion of the remaining resources.

While it is generally agreed that most of the giant oil and gas fields have already been discovered, geologists and geophysicists also agree that there is much remaining oil and gas yet to be discovered. However, we are going to need new and better techniques for finding these energy resources and a greater understadning of how geopressured methane, deep gas and methane hydrate reserveirs behave. In my opinion, the current level of funding for geoscience research and development is woefully inadequate to meet the pressing need for domestic oil and gas production capability into the next century.

Why am I so concerned? With the major oil and gas producers in the process of leaving the domestic onshore playing field, a substantial amount of R&D capability is leaving with them. The independents, who are purchasing these properties and have traditionally been the explorationists, cannot support this type R&D themselves due to their relatively small size.

While I am aware of the budget imperatives, I believe we can accomplish these objectives by raising the funding levels within the R&D budget for this research without raising the overall funding levels. I have been working with the gentleman from Oklahoma, Mr. McCurdy and I know of the gentleman from Texas, Mr. Barton's, interest in this area, which is of vital interest to our states.

I have some questions but am not prepared to ask them at this time. With the Chairman's consent, I would like to submit to the Departmental witness some questions in writing to be made a part of this record.

Thank you Mr. Chairman and I yield back the balance of my time.

Opening Statement
Honorable Dave McCurdy of Oklahoma
Subcommittee on Energy Development and Applications
Committee on Science and Technology
Hearing on DOE FY87 Budget
March 4, 1986

I would like to focus on the petroleum research part of the fossil energy budget. Some of us on this panel are very disturbed by the program direction that is being charted by the Department. The lower-48 states continue to experience a dramatic drop in oil production. Much of this decline is in key producing states represented by members of this panel -- New Mexico, Texas, Oklahoma and Illinois. Should this trend continue, many states will be out of the oil business. Then I am sure that Saudi Arabia and other OPEC countries would be more than happy to make up for our shortcomings.

How do we reverse the drop in domestic production and ensure better energy security? One way is to go after oil that has been abandoned in known U.S. reservoirs. By some estimates there are 300 billion barrels yet to be extracted from such wells. Only enhanced oil recovery methods can reach this oil. The federal government has a clear role in developing EOR and other extraction technologies.

The sooner this work yields the models and data needed, the sooner the independent producers -- the "little guys" of the industry -- can go after our abandoned resources. The public is greatly served by the basic, long-range petroleum research that is done by our universities and the National Institute of Petroleum and Energy Research. Dr. Mankin of the Oklahoma Geological Survey will testify later today on the potential in this area. I am interested in Assistant Secretary Bauer's assessment as well.

DOE must make petroleum research more of a priority in coming years. In Oklahoma, we call an unsuccessful well a dry hole. Implementing this budget would be like drilling a dry hole. Faced with that prospect, the Committee should do as an Oklahoma wildcatter would do. When he knows it's a dry hole -- he drills somewhere else.

Mr. Fuqua. Thank you.

Our first witness will be Donald L. Bauer, Acting Assistant Secretary for Fossil Energy. Mr. Bauer, we will be pleased to hear from you at this time.

Mr. Bauer. Thank you and good morning, Mr. Chairman and other members of the subcommittee.

I have submitted a detailed statement for the record. In the interest of time——

Mr. Fuqua. We will make that in its entirety part of the record.

Mr. Bauer. Thank you very much. In the interest of time, I will be very brief in my opening remarks.

STATEMENT OF DONALD L. BAUER, ACTING ASSISTANT SECRETARY FOR FOSSIL ENERGY, U.S. DEPARTMENT OF ENERGY, ACCOMPANIED BY JEREMIAH WALSH, DEPUTY ASSISTANT SECRETARY FOR MANAGEMENT, PLANNNING, AND TECHNICAL COORDINATION; RICHARD E. HARRINGTON, DEPUTY ASSISTANT SECRETARY FOR COAL UTILIZATION, ADVANCED CONVERSION AND GASIFICATION; AND KEITH N. FRYE, DEPUTY ASSISTANT SECRETARY FOR OIL, GAS, SHALE, AND COAL LIQUIDS

Mr. Bauer. I have with me today several members of the fossil energy staff, who can assist me in answering your detailed questions. At the table with me this morning is Deputy Assistant Secretary Jerry Walsh, who is Assistant Secretary for Management, Planning and Technical Coordination.

Seated in the first row behind me you will find Mr. Richard Harrington and Mr. Keith Frye, two Deputy Assistant Secretaries that oversee the overall Fossil Program.

Mr. Chairman, the administration's proposed budget for fossil energy R&D is $150.1 million in total budget authority. This request was fashioned from the same fiscal principles and goals that make up the President's overall budget submission, a budget submission that meets the targets imposed by the Gramm-Rudman-Hollings legislation.

The fossil energy budget request would maintain adequate spending levels for those activities and functions that would otherwise not be pursued by the private sector; that is, generic, high-risk, long-term research.

It ensures that adequate funds are available for research that truly benefits the general population, for example, Federal assistance for technologies that can economically manage the environmental impacts of fossil fuels.

It continues to build on a broad base of scientific data that will help shape the fossil fuel technologies of the 21st century.

But perhaps more importantly, by reflecting this administration's commitment to fiscal constraints, the fiscal year 1987 budget request will do its fair share in helping bring Federal spending under control.

Specifically, the administration's fiscal year 1987 budget request for fossil energy R&D can be summarized as follows: $82.2 million would be allocated for coal R&D; $9.9 million would be used for petroleum research; $5.3 million would go to unconventional gas research; $40.2 million would be needed to support management and program direction costs; and $12.5 million would be set aside for an initial program in cooperative research and development ventures, which I will discuss in just a moment.

The total of these moneys, $150.1 million, would be offset by nearly $67 million in prior year funds and construction program transfers. Therefore, the new budget authority amounts to just under $83 million.

As I mentioned, our request includes a new initiative for a cooperative R&D venture approach in fossil energy. This new approach would be used in the applied research area focusing upon general categories of extraction-related technologies that we believe will attract significant industrial interest, including unconventional gas recovery, enhanced oil recovery, oil shale processing, and underground coal gasification.

This initiative is intended to give the private sector a greater role in establishing Federal R&D priorities. It will help us ensure that tax dollars are applied to those research efforts that are most relevant to the trends and objectives of the marketplace. It will assist in the transfer of taxpayer-supported technology from the Government to industry. And it will provide greater leverage for Federal dollars by increasing private sector cost sharing.

We recognize that additional details must be developed before this initiative can be implemented. Therefore, we intend to work very closely with Congress in developing this viable, effective venture pool approach that results in effective expenditure of tax dollars.

I would also mention, Mr. Chairman, that in addition to the funds requested for conducting the fundamental research program in fossil energy, the Department is also carrying out the congressionally directed Clean Coal Technology Program, budgeted at $397.6 million for fiscal year 1986 through fiscal year 1988.

On February 17, 1986, the Department issued a program opportunity notice outlining the program's objectives, the evaluation criteria, and the information requirements for prospective proposers.

In accordance with the Public Law 99-190, which made the funds available, the Department will require a minimum of 50 percent cost sharing of the project costs by the private sector. The Department will also require that such cost sharing be on a dollar-by-dollar basis as expended during each phase of the project. To ensure the broadest spectrum of cost-shared clean coal projects, the Department will accept proposals in all energy market applications. As required by the act, proposals are due by April 18, and selection will be made on or before August 1.

When the Clean Coal Technology Program is complete, the demonstration projects it will have financed are expected to provide sufficient technical, economic, environmental, health and safety, and operational information at sufficient scale and detail to enable the private sector to make future decisions.

That completes my opening statement, Mr. Chairman. I would be pleased to answer any questions you may have.

[The prepared statement of Donald Bauer follows:]

Statement of Donald L. Bauer
Acting Assistant Secretary for Fossil Energy
U.S. Department of Energy

Before the

Committee on Science and Technology
Subcommittee on Energy Development and Applications
U.S. House of Representatives

March 4, 1986

FY 1987 FOSSIL ENERGY BUDGET REQUEST

On February 5, 1986, President Reagan sent to the U.S. Congress his proposed federal budget for fiscal year 1987 — the first budget submitted in the Gramm-Rudman-Hollings era.

Contained within the Administration's proposed budget is a request for $150.1 million in total budget authority to continue fossil energy research. The request — part of approximately $1.82 billion proposed by the Energy Department in FY 1987 for energy research and development — embodies many of the same fiscal principles and goals as the President's overall budget submission.

It maintains adequate spending levels for those functions that would not otherwise be pursued by the private sector, i.e., generic, high-risk, long-term research. It ensures that adequate funds are available for research that truly benefits the general population, i.e., federal assistance for technologies that can economically manage the environmental impacts of fossil fuels. It continues to build a broad base of scientific data that will help shape the fossil fuel technologies of the 21st Century.

But perhaps most importantly, by reflecting this Administration's commitment to fiscal constraint, the FY 1987 Fossil Energy budget request will do its fair share in helping to bring federal spending under control and removing the last remaining obstacle to a future of continued economic growth.

Specifically, the Administration's FY 1987 budget request for Fossil Energy Research and Development can be summarized as follows:

	Budget Authority	
Coal	$ 82.227 million	
Petroleum	9.890 million	
Gas	5.252 million	
Program Direction & Management Support	40.221 million	
Cooperative Venture Pool	12.500 million	
Subtotal		$ 150.090 million
Prior Year Offsets	- 64.811 million	
FE Construction Transfer	- 2.075 million	
Appropriation Transfers	- .437 million	
Subtotal		$ -67.323 million
TOTAL (new Budget Authority)		$ 82.767 million

DEFERRALS AND OTHER OFFSET/TRANSFERS

As the above table shows, the Energy Department is proposing to conduct a fossil energy research program in FY 1987 at a total funding level of slightly more than $150 million. However, this budget figure can be significantly reduced in line with the Administration's funding priorities by applying currently unspent funds principally from those added in FY 1986 during the Congressional appropriations process. These proposed deferrals are associated with the following programs (FY86 proposed deferral amount is in parentheses): magnetohydrodynamics ($13.130 million), fuel cells ($22.056 million), surface coal gasification ($ 8.008 million), coal liquefaction ($ 6.329 million), control technology and coal preparation ($ 4.375 million), advanced research and technology development ($ 2.096 million), combustion systems ($ 6.951 million), heat engines ($ 1.428 million), oil shale ($ 2.856 million), program direction and management support ($ 0.476 million).

In addition to the proposed deferrals, the FY 1987 fossil energy budget can be further offset by applying appropriation transfers of $2.075 million in unspent funds from prior year construction projects and $0.437 million in fees previously deposited in the "Energy Security Reserve" for guarantees of obligations for the Great Plains Coal Gasification Project.

COOPERATIVE R&D VENTURES POOL

The FY 1987 budget request includes a new initiative for a cooperative R&D venture approach in fossil energy. This new approach would be used in the applied research area, focusing upon general categories of technologies that are sufficiently mature to attract significant industrial interest.

In FY 1987, the Fossil Energy program proposes to make available $12.5 million for an initial phase-in effort that will help us to determine the best strategy for applying the cooperative venture mechanism, to stimulate interest within different parts of the energy industry, and to develop practices that will help us realize, as much as possible, the benefits of this approach.

Initially, the Fossil Energy program will confine the cooperative R&D venture pool to extraction-related technologies, such as:

- unconventional gas recovery
- oil shale processing
- enhanced petroleum recovery
- underground coal gasification

The program will also be open to other R&D concepts applied to U.S. deposits of oil, gas and shale that might be brought to the Department for consideration.

We recognize that there may be some initial reluctance in the marketplace to shift toward a different funding approach for industrial performed energy R&D. But that should not argue against the increased economic efficiency, market penetration, and more effective technology transfer offered by an improved funding mechanism. The cooperative venture initiative is intended to give the private sector a greater role in establishing federal R&D priorities. It will help ensure that tax dollars are applied to those research efforts that are most relevant to the trends and objectives of the marketplace. It will assist in the transfer of taxpayer-supported technology from the government to industry. And it will provide greater leverage for federal funds by increasing private sector cost-sharing.

The Department will not place tight constraints on the types of cooperative opportunities to be considered. As currently envisioned, however, the proposed program would solicit proposals with the following common characteristics:

- DOE will be a minority funding partner with at least two other industrial partners; the federal share will provide a maximum of 49 percent of the total funding for the venture;
- Assurance must be available that federal funds will not be displacing private sector funds;
- The taxpayer must be able to share in royalties or other profits from the venture, consistent with the government's funding contribution;
- Preference will be given to companies with a proven record of successfully obtaining and managing co-funding from private sources.

We recognize that additional details must be developed before this new initiative can be implemented. Therefore, we intend to work closely with Congress in developing a viable, effective venture pool approach that results in an efficient expenditure of tax dollars.

Further discussion of the FY 1987 Cooperative R&D Ventures Pool initiative can be found on pages 25-26 of this testimony.

CLEAN COAL TECHNOLOGY PROGRAM

In addition to the funds requested for conducting a basic and applied research program in fossil energy, the Department will also carry out the Congressionally-directed Clean Coal Technology Program, budgeted at $397.6 million for fiscal years 1986 through 1988.

On February 17, 1986 the Department issued a "Program Opportunity Notice" outlining the program's objectives, the evaluation criteria and the information requirements for prospective proposers. In accordance with Public Law 99-190, which made the funds available, the Department will require a minimum of 50 percent sharing of project costs by the private sector. The Department will also require that such cost sharing be on a dollar-for-dollar basis as expended during each phase of the selected projects. To ensure the broadest spectrum of cost-shared clean coal projects, the Department will accept proposals in all energy market applications. As required by P.L. 99-190, proposals are due on April 18, 1986, and selection of prospective projects will be made on or before August 1, 1986.

When the Clean Coal Technology Program is complete, the demonstration projects it will have financed are expected to provide sufficient technical, economic, environmental, health and safety, and operational information at sufficient scale to enable the private sector to make rational commercialization decisions.

Additional details on the Clean Coal Technology Program can be found on pages 27-28 of this statement.

The following pages contain a more detailed description of the proposed FY 1987 Fossil Energy budget organized by major activity:

- COAL -

CONTROL TECHNOLOGY AND COAL PREPARATION

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised[1/]	FY 1987	Percent Change from FY 1986
Operating Expenses	$34.8	$33.3	$31.9	$18.1	-43.3%
Deferral to Finance FY87	...	...	-4.9	...	...
Total	$34.8	$33.3	$27.0	$18.1	-33.0%

[1/] Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

Coal preparation is directed toward the development of advanced coal cleaning technologies that will reduce the ash and sulfur content of U.S. coals. The resultant product can be formulated into a high quality fuel that could replace oil and/or gas and reduce environmental emissions of suspected acid rain precursors from coal-fired power plants in both new and retrofit applications.

The FY 1987 coal preparation budget proposal of $6,443,000 provides funds to:

- o Complete design of pre-proof-of-concept Gravimelt chemical coal cleaning system. ($1,000,000)
- o Continue investigation of advanced concepts for chemically modified coals. ($1,300,000)
- o Continue joint DOE/EPRI advanced coal cleaning development and test program. ($1,000,000)
- o Continue research to optimize techniques for microbial removal of organic sulfur from coal. ($1,000,000)
- o Continue ultrafine coal characterization and process economics. ($500,000)
- o Continue in-house research on chemical coal cleaning, and fundamental organic sulfur chemistry. ($500,000)
- o Continue laboratory scale research on advanced physical cleaning concepts. ($1,143,000)

Flue gas cleanup addresses the removal of pollution causing contaminants from the stack gases of conventional combustion units to meet environmental standards. Efforts will be focused on fundamental research for processes for the combined removal of NO_x, SO_x, and particulates, both for utility and industrial applications.

The FY 1987 funding request of $7,541,000 would:

- Complete proof-of-concept test and evaluation for low temperature dry hydrate and dolomitic lime slurry in-duct injection for acid rain precursor control technology process candidates. ($3,390,000)
- Continue research on advanced NO_x/SO_2 chemistry and bench scale advanced concept development. ($2,341,000)
- Continue fluidized bed copper oxide proof-of-concept test and evaluation. ($1,810,000)

Gas stream cleanup includes the technology for removal of contaminants from gasifier and combustor process streams prior to utilization in advanced power conversion cycles such as gas turbines and fuel cells. Both hardware and environmental protection are key concerns.

The $3,839,000 in funds requested for FY 1987 would:

- Continue alkali combustion chemistry research. Work will be performed by Midwest Research Institute in Kansas. ($350,000)
- Continue process modification R&D for trace contaminants. ($75,000)
- Continue R&D for sulfur removal with selected sorbents. ($788,000)
- Continue process modification R&D for direct-fired turbine. ($1,000,000)
- Complete on-line tests of remaining selected particulate and sulfur removal devices for turbine combined cycle. ($600,000)
- Continue test and evaluation of soot, particulate control, and trace contaminants. ($100,000)
- Continue basic research for physical and chemical cleanup for gasifier PFB and direct coal-fired turbines including instrumentation and control. ($926,000)

Waste management focuses primarily on waste sampling and characterization from coal preparation wastes. The FY 1987 funding request of $324,000 would:

- Continue sampling and characterization and data acquisition of organic and inorganic compounds present in solid wastes and in their leachates. ($195,000)
- Complete Phase I R&D for extracting energy from coal preparation wastes. ($129,000)

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$30.8	$35.2	$33.8	$27.2	-19.5%
Deferral to Finance FY87	...	...	-2.1	...	...
Total	$30.8	$35.2	$31.7	$27.2	-14.2%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The Advanced Research and Technology Development Program is directed toward the scientific and technical areas that underlie the development of all fossil energy technologies. Included are fundamental studies to increase understanding of the mechanisms of direct coal combustion, generic studies of materials and components, and investigations of instrumentation concepts in environments associated with advanced coal technologies.

AR&TD differs from the Fossil Energy line programs; the latter have an end-item technology development orientation while AR&TD's mission is to pursue generic research in support of all Fossil Energy coal line programs.

The $27,224,000 requested for AR&TD would be applied as follows:

Direct Utilization ($9,415,000)

- Continue research on the determination of physical and chemical properties of uncombusted coals and combustion products. ($950,000)
- Continue support research on coal combustion science and IEA coal combustion science program. ($4,643,000)
- Continue research on deposition mechanisms and erosion caused by mineral matter in atmospheric, internal combustion, and pressurized environments. ($1,845,000)
- Continue research on separation mechanisms relevant to the coal fuel cycle, from coal beneficiation to the removal of environmentally deleterious products of combustion. ($1,127,000)
- Continue generic electrochemistry research and research on fundamental aspects of molten carbonate and solid oxide fuel cells. ($850,000)

Materials ($5,860,000)

- Perform mechanistic research necessary to allow development and use of new corrosion and erosion resistant alloys, ceramics and refractories for use in coal conversion and utilization systems. ($5,860,000)

Components ($1,593,000)

- Conduct studies on novel component concepts to mitigate erosion and wear in seals; and on slurry flow control devices. ($650,000)
- Conduct fundamental research at national labs and PETC on bulk flow modeling, solids-liquid rheology, and dense phase solids-gas flow; eliminate support for university research in solids transport. ($943,000)

Environmental Activities ($2,200,000)

- Continue analyses of issues associated with air and water quality, solid waste disposal, and toxic substances; continue support of occupational health and safety compliance services. ($1,550,000)
- Continue research conducted under ITFAP with reduced emphasis on quality assurance of data and analytical tools. ($650,000)

Technical and Economical Analysis ($2,000,000)

- Continue funding studies which support multi-year planning and FE strategy and program formulation, technical/economic assessment studies that crosscut a number of FE programs, and support of IEA/Coal Research Service. ($2,000,000)

Technology Base Synthesis ($800,000)

- o Continue analyses and studies to integrate and coordinate research and exploratory development activities, to identify advanced research needs, to support international collaborative research activities in FE, and to provide seed funding for new advanced research initiatives. ($800,000)

Instrumentation, Control and Diagnostics ($1,356,000)

- o Perform research on unique methods for measuring multiphase flow parameters such as velocity, solids content, and viscosity; and for identifying chemical species such as plasma spectrographic techniques. ($1,356,000)

University Coal Research ($4,000,000)

- o Initiate approximately 20 new university projects relating to coal science, environmental science, surface science, organic and inorganic chemistry of coal constituents and the mechanisms and kinetics of chemical reactions to gasification, liquefaction and combustion; encourage collaboration between university and industrial researchers. ($4,000,000)

COAL LIQUEFACTION

(Dollars In Millions)

		FY 1986			Percent Change from
ACTIVITY	FY 1985	Approp.	Revised 1/	FY 1987	FY 1986
Operating Expenses	$31.1	$32.9	$31.6	$9.1	-71.2%
Deferral to Finance FY87	...	...	-6.3	...	...
Total	$31.1	$32.9	$25.3	$9.1	-64.0%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The Coal Liquefaction program is developing the scientific and engineering knowledge base which industry can use to bring economically competitive and environmentally acceptable synthetic liquid fuel technology into the marketplace when needed.

The FY 1987 budget request of $ 9,147,000 would be used as follows:

Advanced Research ($2,620,000)

- o Conduct exploratory efforts on novel coal liquefaction processes. ($200,000)
- o Continue research to improve the understanding of coal liquefaction including properties of coal, reaction mechanisms, utilization of hydrogen, and properties of coal liquids. ($1,120,000)
- o Continue research on biological approaches to coal liquefaction. ($100,000)
- o Continue research on novel catalytic approaches to coal liquefaction. ($450,000)
- o Continue research on the physical, chemical and thermodynamic properties of fossil fuel liquids. ($750,000)

Indirect Liquefaction ($2,539,000)

- o Continue catalyst research, study reaction mechanisms and more promising process concepts at PETC and with industry. ($2,539,000)

Direct Liquefaction ($2,996,000)

- o Continue in-house research of advanced process concepts at PETC while completing existing bench scale industrial projects. ($2,996,000)

Support Studies/Engineering Evaluations ($992,000)

- o Complete one existing industrial instrument research project. ($37,000)
- o Continue technology base research and an existing industrial research project ($955,000)

COMBUSTION SYSTEMS

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$30.1	$30.3	$29.1	$9.2	-68.4%
Deferral to Finance FY87	...	...	-1.0	...	...
Total	$30.1	$30.3	$28.1	$9.2	-67.3%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The goal of the Combustion Systems activity is to increase the contribution of the nation's coal resources through the development of market-suitable combustion systems and fossil-derived fuels. The programs within the overall Combustion Systems activity are Atmospheric Fluidized Bed, Pressurized Fluidized Bed, Alternative Fuels and Advanced Combustion Technology.

The FY 1987 funding request of $9,169,000 would be used as follows:

Atmospheric Fluidized Bed Combustion ($1,590,000)

- Conduct in-house fluidization research in particle motion flow, erosion, bed internals and heat transfer surfaces. ($490,000)
- Initiate bench scale construction and testing of special AFB applications for the commercial/institutional and residential sectors. ($1,100,000)

Pressurized Fluidized Bed Combustion ($3,686,000)

- Continue ongoing program at New York University to evaluate PFB components and design changes to enhance performance and provide the basis for advanced concept designs. ($600,000)
- Continue research on PFB dynamics, systems analysis, and combustion characterization; continue technology and economic analysis assessments. ($586,000)
- Continue the follow-on test program to obtain POC on hot gas cleanup, coal/water slurry feeding, and performance of updated heat exchanger design. ($1,500,000)
- Complete Phase I systems definition studies including conceptual design and cost of a commercial plant. Initiate Phase II, development and testing of key critical process components. ($1,000,000)

Advanced Combustion Technology ($1,882,000)

- Continue development of the most promising of the light industrial, commercial and residential concepts selected including design, fabrication and testing. ($1,400,000)
- Continue in-house activities supporting advanced combustion technology systems. ($482,000)

Alternative Fuels ($2,011,000)

- o Complete detailed combustion and system characterization and technical, economic, and environmental assessments on selected existing residential boiler/furnance systems firing CLM/micro-coal fuels. ($2,011,000)

FUEL CELLS

(Dollars in Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$40.5	$35.4	$34.1	$5.0	-85.3%
Deferral to Finance FY87	...	...	-22.1	...	...
Total	$40.5	$35.4	$12.0	$5.0	-58.3%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The Fuel Cell program supports high risk, high payoff technology base development to assist private industry in developing hydrocarbon fuel conversion technologies. Fuel cells, which rely on an electrochemical reaction rather than combustion, can potentially increase the cost effectiveness, efficiency, and environmental acceptability of conventional and alternative hydrocarbon fuels.

No funds are requested in FY 1987 for phosphoric acid fuel cell systems. The objective for this program will have been achieved by the end of FY 1986 and full responsibility for further development and application of phosphoric acid fuel cell technologies should be left to the private sector.

The technical feasibility of molten carbonate fuel cells operating at approximately 60 percent electrical conversion efficiency (natural gas to busbar) has been forecasted by single cell testing. The complexity and associated capital costs of advanced fuel cell systems are projected to be less than those for first generation phosphoric acid fuel cell systems. The $3,400,000 requested for the molten carbonate fuel cell will be used to:

- o Continue development of external and/or internal reforming molten carbonate stacks. ($2,600,000)
- o Continue technology base research on cell components and corrosion resistant materials. ($800,000)

The solid oxide fuel cell is an advanced, high temperature solid state fuel cell that offers promise in electric utility and in cogeneration applications in industrial and commercial sectors. Solid oxide electrolyte fuel cells have the advantage of solid state stability and have been projected to be more easily manufactured than other fuel cell concepts. The $1,600,000 requested for the Advanced Concepts fuel cell activity would:

- Complete testing of a 5 kW solid oxide fuel cell module and continue development of a 25 to 200 kW generator. ($1,600,000)

HEAT ENGINES

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expense	$11.8	$12.8	$12.3	$7.9	-35.8%
Deferral to Finance FY87	...	...	-1.4	...	...
Total	$11.8	$12.8	$10.9	$7.9	-27.5%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The goal of this program is to establish technical data which will enable the private sector to assess the commercial viability of coal-fueled power conversion systems. The program focuses on key technical problems associated with substituting coal or coal-derived gaseous fuels for distillate fuels or natural gas in gas turbine and diesel power conversion systems. The goal is to assist the private sector, through selected research efforts, in developing the technology needed for direct firing of coal, either dry or suspended in a liquid carrier, or a coal-derived gaseous fuel cleaned at minimal cost.

The $7,942,000 in requested funds for FY 1987 will be used as follows:

Gas Turbines ($6,394.000)

- o Complete first portion of the integrated systems test program. ($5,994,000)
- o Continue evaluation of coal-liquid mixtures in the gas turbine combustor test stand. ($400,000)

Diesels ($1,548,000)

- o Continue evaluation of coal-liquid mixtures in the diesel engine test facility. Initiate research activities related to the FY 1986 Program Research and Development Announcement for the coal-fired diesel engine integrated systems test validation. Complete technical and economic analyses and related experimental tests of the coal-fired diesel engine project. ($1,548,000)

UNDERGROUND COAL GASIFICATION (Dollars In Millions)

		FY 1986			Percent
ACTIVITY	FY 1985	Approp.	Revised[1]	FY 1987	Change from FY 1986
Operating Expenses	$ 5.7	$ 4.2	$ 4.1	$ ...	-100.0%

[1] Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

Underground Coal Gasification (UCG) is a process for converting coal, in place (in situ), to a readily cleanable synthetic gas comparable to that produced from surface gasification systems. The energy for the process is derived from partial combustion of the coal (pyrolysis) resulting in the identical reactions that occur in aboveground gasification. The technical feasibility of underground gasification techniques applied to several types of coal resources has been proven. In FY 1986 and FY 1987 ongoing technology base activities will be phased out. In FY 1987 industrial-proposed applied research efforts will be candidates for the cooperative R&D venture pool.

Gasification Technology Development ($0)

- o Complete technology base development using prior year funds.

Environmental and Advanced Research ($0)

- o No activity.

MAGNETOHYDRODYNAMICS

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised[1/]	FY 1987	Percent Change from FY 1986
Operating Expenses	$30.7	$28.9	$27.7	$ ...	-100.0%
Deferral to Finance FY87	...	...	-13.1	...	...
Total	$30.7	$28.9	$14.6	$ ...	-100.0%

[1/] Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The current MHD program continues the implementation of the June 1984 cost-shared multiyear program which provides for basic supporting research and the development of systems/subsystems which will provide proof-of-concepts needed for the advancement of the MHD technology to the retrofit stage.

No funds are requested for MHD research in FY 1987. The Department believes that the cost of continuing its MHD program is not affordable in light of current fiscal constraints. Other technologies can contribute more directly to the nation's energy security with lower investment requirements, in a more timely manner and with significantly more cost-sharing.

SURFACE COAL GASIFICATION

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised[1/]	FY 1987	Percent Change from FY 1986
Operating Expenses	$35.1	$43.0	$41.3	$5.6	-86.4%
Deferral to Finance FY87	...	...	-8.0	...	...
Total	$35.1	$43.0	$33.3	$5.6	-83.2%

Specific programmatic goals of the Surface Coal Gasification Program are to: (1) advance the state-of-the-art of Surface Coal Gasification technology to optimize its potential for development of more viable or advanced gasification systems through the study of promising long term, high risk concepts, (2) identify and support those R&D efforts that will make available the full capabilities and processing flexibility of surface coal gasification systems as the key coal conversion technology directly applicable for generating alternative energy options from coal for every sector of the energy consuming marketplace, and (3) continue management and monitoring of the Great Plains Gasification project as necessary.

The $5,598,000 requested for FY 1987 would be applied to the following research efforts:

Advanced Research ($968,000)

- Continue research on the fundamental chemistry and reaction mechanisms associated with mild gasification and investigate the parameters that control product yield distribution. ($593,000)
- Continue research on the chemistry of ash and slag from coal gasifiers ($375,000).

Advanced Process Development ($1,689,000)

- Complete studies on advanced staged, concurrent rapid rate reactors to enhance data base on rapid rate pyrolysis. Continue characterization of char during devolatilization. ($309,000)
- Continue studies using coal based sorbents and zeolites in pressure swing adsorption for separation of gases. Continue development of low cost, highly selective permeable membranes for hydrogen separation. ($235,000)
- Continue operation of the advanced gasification concepts facility to generate data essential to advancing entrained gasification and hot gas cleanup technology. ($192,000)
- Continue theoretical studies on coal gasifiers and gasification systems needed for design of optimized systems. ($703,000)
- Redirect and continue essential studies leading to economic production, upgrading and use of new fuel forms. ($250,000)

Systems Engineering Concepts ($1,373,000)

- Continue to investigate parameters controlling the use of minimally cleaned gasifier coal products as fuels for advanced heat engines. ($50,000)
- Continue effort to develop more economical methods for production of oxygen in large quantities--advance the solid state zirconia system to the "process development unit" stage of study. ($350,000)

- Utilize results of studies on composite sorbents, mixed metal oxides, catalysts, etc. to establish reaction mechanisms by which gasifier performance can be controlled through use of in-bed/coal-feed additives. ($200,000)

- Continue key studies on integration of gasifiers/gasification technologies with other conversion systems to determine the most optimum configurations and on identification of problems requiring R&D effort to resolve. ($173,000)

- Continue to provide engineering analyses and systems evaluation capability for joint DOE/GRI Coal Gasification Program through monitoring processes, review of technical data and economic assessments. ($600,000)

- Continue the "process development unit" effort exploring issues limiting the integration and development of gasifier/advanced hot gas cleanup systems/turbines for the production of power. ($0) (Prior year funding)

Environmental and Engineering Analysis ($1,131,000)

- Continue the development of process modifications that will reduce the generation of trace hazardous compounds. ($375,000)

- Complete the study of novel approaches to use microorganisms for removing trace amounts of organic contaminants in waste water. (Prior year funding) ($0)

- Continue development of analytical models such that computer based systems analysis can be used to identify advanced gasifier systems--expand efforts to prepare environmental information for entry into the model. ($200,000)

- Investigate new and novel methods for sampling and analyzing organics, sulfur species, nitrogen, trace elements, etc., and study ways to reduce toxicity of oils and tars. ($186,000)

- Initiate comprehensive environmental sampling and analysis of systems employing hot gas cleanup systems. ($200,000)

- Initiate the environmental assessment of those processes found suitable for production of new fuel forms. Make recommendations on areas of study needed to minimize the impact of those mild gasification processes that produce liquids derived from coal. ($170,000)

Great Plains ($437,000)

- Continue management/monitoring of the Great Plains project as necessary. ($437,000)

- PETROLEUM -

ADVANCED PROCESS TECHNOLOGY

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised[1]	FY 1987	Percent Change from FY 1986
Operating Expenses	$5.4	$5.7	$5.5	$1.8	-67.3%

[1] Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

There are two goals within the APT Program. These are: (1) to pursue the fundamental research relevant to oil, gas, and shale recovery, i.e., development of the tools and techniques to measure and predict important properties and phenomena, and to obtain the fundamental data critical to these recovery processes; and (2) to provide the proper environment to conduct research and to pursue application of new frontiers of science and/or as yet unexplored new concepts to achieve quantum increases in recovery efficiency for oil, gas, and shale resources.

The $1,811,000 requested for this activity would be used as follows:

Advanced Exploratory Research ($1,576,000)

- Continue fundamental petroleum, geoscience and chemistry research focusing on physical and chemical characterization studies of heavy oil; thermodynamic measurements; shale oil and tar sands bitumen studies and fuel storage and handling. Work will be performed by the National Institute for Petroleum and Energy Research. ($1,500,000)
- Continue extraction related aquifer contamination studies. ($76,000)

Arctic and Offshore Research ($235,000)

- Continue the Arctic/offshore oil and gas research data base. ($235,000)

ENHANCED OIL RECOVERY

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised[1/]	FY 1987	Percent Change from FY 1986
Operating Expense	$11.7	$11.9	$11.5	$4.5	-60.9%

[1/] Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The goal of the Enhanced Oil Recovery (EOR) program is to conduct generic technology base R&D activities; develop fundamental knowledge that can lead to improved and new process concepts; and to assist industry in obtaining a better understanding of the mechanisms and behavior of advanced and novel EOR processes for the recovery of presently unrecoverable light oil, heavy oil and tar sand resources. In addition to specific funding listed below, technology programs in this area will be eligible for support through the industry cooperative R&D venture pool.

Funding requested in FY 1987 totals $4,484,000, applied as follows:

Heavy Oil ($608,000)

- Continue studies of steam additive mechanics and variables affecting mobility control and sweep efficiency. ($608,000)
- Complete remaining joint research with Venezuela and Mexico using previous EOR technical base funds. ($0)
- Complete, utilizing prior year funding, final report on variables in alkaline flooding in EOR. ($0)

Light Oil ($3,876,000)

- Investigate high temperature, stable polymer systems and continue fundamental surfactant studies. ($1,150,000)
- Complete post-field test analyses of EOR field tests and continue reduced studies of geologic heterogeneities and other characteristics on EOR process shortcomings. ($1,100,000)
- Continue environmental study of microbial EOR processes. ($100,000)
- Conduct basic multi-phase flow wettability studies to understand EOR process mechanisms. ($700,000)

- o Continue studies of CO2 and other gas flooding concepts with emphasis on mobility control. ($826,000)

Tar Sands ($0)

- o No funds requested.

OIL SHALE

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$14.6	$12.6	$12.1	$3.6	-70.2%
Deferral to Finance FY87	...	...	-2.9	...	...
Total	$14.6	$12.6	$ 9.2	$3.6	-60.9%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The goal of the Oil Shale R&D program is to provide a sound technologic basis for reduction of economic and environmental constraints to industrial development of the U.S. oil shale resources and to increase the amount of resource that may be used economically. The program is focusing on basic research using reference shales to systematically study the chemistry, kinetics, and emissions related to eastern and western shale processing. In addition to the specific funding listed below, technology programs in this area will be eligible for support through the industry cooperative R&D venture pool.

The $3,595,000 requested for FY 1987 would be used to support the following research:

Oil Shale Technology Base ($3,078,000)

- o Complete specific eastern shale research resulting from FY 1985 unsolicited proposals in the areas of hydroretorting and in situ processing. ($1,450,000)
- o Continue developing a systems analysis capability to enable assessment from mining to spent shale disposal. ($277,000)

- Continue experiments with reference shales in various generic solids recycle retort systems to provide data for modifying and developing chemical, physical, and economic models. Maintain reference shale bank activities including characterization and distribution of shales to program participants. ($1,201,000)

- Continue development and maintenance of an oil shale data base. ($150,000)

Environmental Mitigation ($517,000)

- Continue development of the environmental data base. ($50,000)

- Identify and quantify major and trace element emissions in gases, liquids and solids from reference shales as a function of process parameters such as time, temperature, shale particle size and composition, and retort gas composition. Continue analytical methods development as necessary. Support environmental research and health and safety research under international agreement with Israel and interagency agreement with Bureau of Mines. ($467,000)

- GAS -

UNCONVENTIONAL GAS RECOVERY

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expenses	$10.1	$8.8	$8.5	$5.3	-37.6%

[1/] Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

The specific objectives of the Unconventional Gas Recovery program are to: (1) reduce the uncertainty surrounding the potential magnitude of reserves of the unconventional gas resources and the conditions under which they will be produced; (2) develop and improve extraction technologies to the point of technical readiness for private sector development; and (3) transfer all technical and economic data to industry.

In addition to the specific funding listed below, technology programs in this area will be eligible for support through the industry cooperative R&D venture pool.

Eastern Gas Shales ($355,000)

- o Continue development of the Eastern Gas Shale production technology base; also special geoscience investigations, system analyses, and technology transfer. ($355,000)

Western Tight Sands ($3,582,000)

- o Conduct fracture stimulation research and production testing of remote lens at Multiwell Test facility. ($3,200,000)
- o Continue supporting research modeling, systems analysis, and data base development. ($382,000)

Environmental and Advanced Research ($1,315,000)

- o Continue resource identification and evaluation of gas hydrates and deep source gas. ($273,000)
- o Continue lab analysis of hydrate core and modeling research. ($192,000)
- o Conduct geochemical and geophysical diagnostic tests for gas hydrates on the North Slope of Alaska. ($650,000)
- o Continue evaluation and development gas hydrate extraction/production techniques and data analysis of environmental assessments. ($200,000)

PROGRAM DIRECTION AND MANAGEMENT SUPPORT

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised 1/	FY 1987	Percent Change from FY 1986
Operating Expense	$46.2	$55.3	$53.2	$40.2	-24.4%

1/ Includes reductions in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm-Rudman-Hollings)

This activity provides funding for salaries, benefits and overhead expenses for the management of FE program at Headquarters, and the Energy Technology Centers:

The Headquarters staff is responsible for overall program direction which implements DOE policy and communicates that policy to the Energy Technology Centers, sets program objectives, develops program plans and evaluates alternative program strategies, develops and defends budget requests to the Office of Management and Budget and to the Congress, approves procurement plans, monitors work progress, evaluates projects, and approves revisions in work plans as required to attain program goals.

The Energy Technology Centers support day-to-day project management functions for assigned programmatic areas including contract and National Laboratory monitoring, development and maintenance of project budget, and procurement plans, and other activities related to program and site support.

The Office of the Federal Inspector for the Alaska Natural Gas Transportation System is responsible for coordinating all Federal activities pertaining to the pipeline in order to assure timely, efficient, safe, and environmentally sound construction including the assessment of developments in the world energy market, specifically the U.S. and Canadian oil and gas situation as they affect the Alaska Natural Gas Transportation System.

The $40,221,000 requested for FY 1987 would support the following activities:

Headquarters Program Direction ($11,260,000)

- Provide funds for salaries, benefits, and travel for Headquarters staff and overhead expenses generic to the entire FE program, including SBIR assessments. ($11,260,000)

ETC Program Direction ($28,740,000)

- Provide funds for ETC indirect costs and for site support. ($28,740,000)

Federal Inspector for the Alaska Natural Gas Transportation System ($221,000)

- Continue technical reviews of ANGTS design and/or remobilization packages. ($36,000)
- Complete long-term Frost Heave research using prior year funding. ($11,000)
- Continue development and refinement of Remobilization Encyclopedia. ($10,000)

- o Continue to assess developments in U.S. and Canadian energy markets, and gas exploration and transportation projects in reference to ANGTS. ($33,000)
- o Continue to maintain liaison with project sponsors, producers, other Government agencies, State of Alaska and Canadian Government. ($26,000)
- o Salaries and related expenses for administrative and support functions. ($105,000)

COOPERATIVE R&D VENTURES POOL

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1986 Revised	FY 1987	Percent Change from FY 1986
Operating Expense	$ ...	$ ...	$ ...	$12.5	+100.0%

The goals of the industry cooperative R&D venture pool are to increase the market relevance and penetration of federally funded applied R&D, to increase private sector leverage of federal funds, and to ensure that taxpayer-supported work in industry will benefit the industry and economy at large and not just a single company.

The vehicle for achieving this will be industry formed cooperative R&D ventures. The core of such ventures would be several private firms with at least two from the same industry (that is the distinction between a "cooperative venture" and a "joint venture"). The structure should, however, allow other parties such as investors, universities, institutes, and public laboratories to participate in the partnership as well.

The principal objectives of the program are to:

- o Implement a process by which industry will join with Government in applied research and development activities that will result in products, processes, and technology that will contribute to achieving the energy and technology goals of the United States.
- o Reduce and/or eliminate traditional barriers that have limited the financial and technical cooperation between the private and public sectors (e.g., patent positions, proprietary rights, anti-trust concerns, etc.).
- o Identify a variety of incentives particularly suited to the needs of various venture partners.

In its FY 1987 budget proposal, the Department opted to limit the initial phase-in of the cooperative venture program to extraction technologies. In prior years, the Office of Fossil Energy has significantly increased the knowledge base for oil, gas and shale technologies. The nature of the economics of many of these technologies, coupled with the solid background of relevant industrial firms in participating in joint venture projects, makes extraction technologies prime candidates for an initial effort to examine the feasibility of the cooperative R&D venture pool approach.

The spectrum of efforts anticipated in these areas range from laboratory/bench scale activities through field tests -- precursors to actual commercial deployment and cash flow. The scale will vary from technology to technology and from resource to resource.

For example, many unconventional gas resources have not been defined well enough to develop predictable recovery strategies. Industry and other parties could form a cooperative venture with DOE to develop sufficient data requisite for the next step: design and test of promising recovery concepts. Similarly, in the area of underground coal gasification, primary interest could be focused on modest-scale, pre-commercial field tests to produce the data necessary for the subsequent design and construction of commercial plants. Additionally, interest may be expressed in the use of the technology in otherwise unattractive coals not currently being produced.

Therefore, in FY 1987, $12,500,000 will be made available to:

o Encourage the formation by industry of cooperative R&D ventures (which may also include other parties such as investors, universities, institutes and public laboratories) to offer partnership opportunities to DOE in the following areas: recovery of gas from unconventional sources; enhanced oil recovery; oil shale; and underground coal gasification. ($12,500,000)

CLEAN COAL TECHNOLOGY PROGRAM

(Dollars In Millions)

ACTIVITY	FY 1985	FY 1986 Approp.	FY 1987	Percent Change from FY 1986
Operating Expense	$ ...	$99.4	$149.1	+50.0%

The principal goal of this program is, as stated in Public Law 99-190, "for the purposes of conducting cost-shared clean coal technology projects for the construction and operation of facilities to demonstrate the feasibility of future commercial operation." It is targeted at a wide variety of market applications.

Public Law 99-190 made available a total of $397.6 million for the Clean Coal Technology demonstration program (after the 0.6% general reduction applied across-the-board to programs contained in Public Law 99-190). Of these monies, $25 million will be held in reserve to cover the cost of overruns in the event the Government agrees to share such costs. Also, funds will be set aside for contracting, travel, and ancillary costs incurred by the Department of Energy in implementing the program. All of the remaining funds will be available for award. Under the terms of Public Law 99-190, the funds will become available in three increments as follows: $99.4 million in FY 1986, $149.1 million in FY87, and $149.1 million in FY88.

The Clean Coal Technology Program is related to, but not a direct continuation of, the effort undertaken by DOE following passage of Section 321, Public Law 98-473, 98 Stat. 1874. This section directed the Secretary of Energy to solicit "statements of interest in, and proposals for projects employing emerging clean coal technologies," and submit a report to Congress. In carrying out this Congressional request, DOE received 175 submissions with project values totaling more than $8 billion. On May 1, 1985, DOE submitted its findings in the Report to Congress on Emerging Clean Coal Technologies (NTIS Document Number: DE850154290). The Department also submitted a Supplemental Report to Congress on Emerging Clean Coal Technologies (NTIS Document Number: DE85018356) which further characterized a wide range of clean coal technologies.

Funds for the Clean Coal Technology program subsequently made available by Congress will provide for a competitive solicitation of project proposals and the award of cost-shared federal assistance to those projects that best demonstrate the feasibility of new clean coal technologies for future commercial applications. The issuance of the solicitation, receipt of proposals, and selection of projects will be made in accordance with the timetable established in Public Law 99-190. Specifically, the $149.1 million previously made available for FY 1987 will be used to:

- Support, on a cost shared basis with the private sector, demonstrations of advanced technologies to gather data needed for their ultimate commercialization. ($147,112,000)
- Provide for contractual services and in-house support in performing post award monitoring and technical data base activities. ($1,988,000)

The following page contains a table summarizing the FY 1985-FY 1987 funding for DOE's Fossil Energy research and development program. (The chart does not reflect funding made available for the Clean Coal Technology program since it represents previous appropriations.)

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Budget Authority in Thousands of Dollars)

	FY 1985 Actual	FY 1986 Estimate	FY 1987 Request
COAL:			
Control Technology and Coal Preparation	$ 34,791	$ 31,950	$ 18,147
Advanced Research and Technology Development	30,804	33,849	27,224
Coal Liquefaction	31,110	31,620	9,147
Combustion Systems	30,092	29,113	9,169
Fuel Cells	40,472	34,057	5,000
Heat Engines and Heat Recovery	11,850	12,314	7,942
Underground Coal Gasification	5,705	4,072	---
Magnetohydrodynamics	30,721	27,717	---
Surface Coal Gasification	35,134	41,323	5,598
Subtotal, Coal	250,679	246,015	82,227
PETROLEUM:			
Advanced Process Technology	5,364	5,523	1,811
Enhanced Oil Recovery	11,702	11,454	4,484
Oil Shale	14,628	12,136	3,595
Subtotal, Petroleum	31,694	29,113	9,890
GAS:			
Unconventional Gas Recovery	10,142	8,503	5,252
Subtotal, Gas	10,142	8,503	5,252
POLICY AND MANAGEMENT:			
Headquarters Program Direction	8,273	13,380	11,260
ETC Program Direction	37,907	39,265	28,740
Federal Inspector for the Alaska Gas Pipeline	1,401	511	221
Capital Equipment	4,425	2,865	---
Construction	4,916	3,332	---
Subtotal, Policy and Management	56,922	59,353	40,221
COOPERATIVE VENTURE R&D POOLS	---	---	12,500
Subtotal, Fossil Energy	349,437	342,984	150,090
Use of Prior Year Balances and Other Adjustments	-60,389	-31,030	-67,323
Total, Fossil Energy R&D	$289,048	$311,954	$ 82,767

Mr. Fuqua. Mr. Bauer, you mention in your statement on page 2 that the Department is going to do its fair share in helping bring Federal spending under control. The overall budget reductions are scheduled to be 15 percent in fiscal year 1987. Don't you think you're kind of overdoing your fair share by going more than 50 percent?

Mr. Bauer. Mr. Chairman, when we took a look at the program, and taking into account the passback numbers, and the budget that was allocated for fossil energy, we developed what we thought was a balanced, viable program——

Mr. Fuqua. Passback, now, is that——

Mr. Bauer. The administration's numbers for——

Mr. Fuqua. And it comes back from OMB.

Mr. Bauer. The $150 million.

When you take——

Mr. Fuqua. What did you ask OMB for? What type of cut went from the Department down to OMB?

Mr. Bauer. The budget that was submitted to OMB back on September 15, was like $272.5 million, I believe, Mr. Chairman. If that's incorrect, I will correct the record.

Mr. Fuqua. And what percentage was that compared to passback?

Mr. Bauer. 150 over 272 is probably 50——

Mr. Fuqua. OK.

Mr. Bauer. But when you take, when you really take the thing in its entirety and take in the fact that the budget went to OMB on September 15, the Gramm-Rudman's enactment, which was in early December, the enactment of the 1986 appropriations, the budget submitted to Congress; if we stop for a moment and take a look at fiscal year 1986 and the number that was appropriated, the new BA number, and then efforts that will no longer be continued, I believe that our role is completed. We have satisfied what Congress asked us to do, and that's TVA and Kilngas.

Take those off and take the Gramm-Rudman off, but adding clean coal, and then take a look at the fiscal year 1987 budget request of $150 million, plus the clean coal, which that results in $300 million, that turns out to be like a 27-percent reduction.

Another way I was looking at it was that, if one takes a look at the 1986 also and takes off the deferrals, the amount of reduction from 1986 to 1987 is only like 15 percent. But that is taking the fossil R&D program and adding to it the congressionally directed Clean Coal Technology Program.

Mr. Fuqua. The other parts of the DOE budget, particularly in basic and applied research, have been increased in this year's budget request for fiscal year 1987. But in fossil energy programs, you have cut advanced research and technology programs. Can you explain that inconsistency?

Mr. Bauer. What I can say—and Jerry Walsh is going to talk about the ARTD budget for a moment—when the Department submits its budget to the administration, that Department's request is taken and reviewed in concert with all the other requests. Then there is a decision on the various pieces and what is allocated for that—I don't have available all the factors that led to that decision. But in the fossil area, that was considered to be an appropriate level for total balanced budget, for doing the technology base in the coal area, the cooperative venture allowing for a new initiative, and the Clean Coal Program that a $300 million program for fossil was an appropriate funding level.

Jerry, do you want to talk about the ARTD?

Mr. WALSH. As far as ARTD is concerned, in the context of a $150 million——

Mr. FUQUA. Would you pull the mike a little closer?

Mr. WALSH. In the context of a $150 million budget, ARTD is the largest R&D program. The administration believes we should be pursuing that type of research as opposed to more applied research. In the passback, ARTD was considered to be quite hefty within the context of $150 million budget. We don't consider the cuts to be very significant, even year to year, percentagewise.

Mr. FUQUA. The Department transmitted a request for a supplemental appropriation for the Great Plains project for $1.2 billion. That was to repay the Treasury for an earlier loan that you had received. What happens if Congress decides not to support that request?

Mr. BAUER. Mr. Chairman, when the Great Plains gasification associates defaulted, we had—and since we had guaranteed the loan, the FFB said: OK, you owe us $1.571 billion. We had a default reserve of $673 million. And there was a principal-and-interest payment due at that time. So, we provided them $402 million.

We recognize the interest rate was being charged by the FFB and using the Secretary's signature authority then turned around and reborrowed from Treasury to pay off FFB. So, what we have to do is a correction of the books. We still have outstanding signature authority debt, if you will, with the Treasury Department that needs to be offset.

So, I think, Mr. Chairman, with all due respect, it is a balancing act. The Department is still on the books, if you will, for that billion dollar loan guarantee. It's a paper transaction.

Mr. FUQUA. You propose to terminate the Wilsonville coal liquefaction project as well as the Waltz Mill project. Do you have the specific termination costs for each of those projects?

Mr. BAUER. Mr. Chairman, I believe that the termination costs for Wilsonville is $1.5 million and Waltz Mill's is $1 million.

Mr. FUQUA. And how much would it cost to operate that? What did we spend in 1986 on that?

Mr. BAUER. Mr. Chairman, the amount to complete Wilsonville this year beyond March 20, there is the amount that is up for deferral; and I believe that's $1.33 million. We have available the $1.5 million for deferral. So, I believe the sum of those two numbers, which is $2.83 million, would continue the project through the fiscal year.

Mr. FUQUA. What is the annual operating cost?

Mr. BAUER. Last year we received—it runs about $600,000 to $700,000 a month. It's cost shared on a one-third, two-thirds basis: one-third by EPRI and two-thirds by——

Mr. FUQUA. And that's at the Wilsonville project?

Mr. BAUER. Yes.

Mr. FUQUA. What about Waltz Mill?

Mr. BAUER. Waltz Mill, let's see, do some math calculation—I think it's about $8 million a year, Mr. Chairman.

Mr. FUQUA. $8 million?

Mr. BAUER. $8 million.

Mr. FUQUA. Is that cost shared any?

Mr. BAUER. It's closer to $9 million, Mr. Walsh tells me, closer to $9 million.

Mr. FUQUA. Mr. Boucher.

Mr. BOUCHER. Thank you, Mr. Chairman.

Mr. Bauer, let me direct several questions to you with respect to the Department of Energy's guidelines for implementing the clean coal technology reserve. I think a number of Members of Congress—and I certainly am one—were quite concerned when the Department elected to treat what Congress intended to be a grant program as a loan. I wonder, in view of the fact that the Department has now maintained steadfastly its position that this should be a loan, just how many proposals you are expecting to receive from the private sector.

I am sure you have had some discussions with firms that would normally be expected to participate in this. I wonder what response you're getting in those discussions. How many proposals do you think you will receive?

Mr. BAUER. I have no idea, Mr. Congressman, how many proposals, responses to the program opportunity notice we are going to have. I might say that I think there will be an indication—there are two indicators. The first is that the number of people that either requested or received the final program opportunity notice with the modification that you mention is like 800. The second indicator will be that there is a preproposal conference scheduled in the departmental auditorium on March 6 at 10 o'clock, where people, potential proposers, can come and ask clarifying questions.

Mr. BOUCHER. But you don't have any indication at this point of what level of participation can be expected in terms of the submission of proposals by the private sector?

Mr. BAUER. No; I do not. Because of my role, I have refrained from discussions with outside parties.

Mr. BOUCHER. On the other hand, though, don't you think that you have a responsibility to make sure that this program works? And I can only say that I have received from a number of firms that were quite useful in promoting the adoption of the legislation that provided the $400 million for this program, substantial statements of skepticism as to whether or not this program is going to be viable in view of the fact that the rules have been changed. It's no longer a grant. It's now going to be a loan.

Do you share that concern? Or do you feel that, given the structuring of the program that you have made to date, it's going to be successful?

Mr. BAUER. Two points, Mr. Congressman. The first one was that we did send out a draft opportunity notice for public comment. And we did get comments back from the public. There were a considerable number of comments on that one. So, there was interest and, if you will, concern or issues raised by the parties at that time.

Another point is, in looking at the administrative provisions covering the Public Law 99-190, it talks about in the event that there will be revenues what the Secretary of Energy can do with those revenues. And I don't believe, but I stand to be corrected, that there is anything in the public law that prevents the Department of Energy from recoupment of its investment in that program. That's all we're doing.

And the Secretary, when he testified before, I believe it was Senate Energy and Natural Resources, said that it is his intent for the Government to recoup its investment once a project moves beyond the initial operating phase and begins to earn profits.

Mr. **Boucher**. Well, I, for one, never heard any indication during the course of the passage of the $400 million appropriation from any of the parties concerned, including the Department of Energy, that this program was going to wind up being a loan. It was always assumed by the individuals involved that it would be a grant.

My question to you is not so much the basis on which you have decided to make it a loan but whether or not you think it's going to work in view of the fact that you have determined to make it a loan. I still hear substantial skepticism from the private sector, and I am just wondering if you hear that.

Mr. **Bauer**. I believe that the program as presently structured is a viable workable program, particularly now that the proposer, if he is, one, selected for negotiation—well, first of all, he now knows that revenues can be retained during the operating phase. No. 2, another part that was put into that modification or revision to the final PON dated February 17, said: "Proposer, if you are selected for negotiations, you can propose to us a recoupment plan and how you plan to permit the Federal Government and the taxpayer to recoup the taxpayer's investment."

Mr. **Boucher**. Well, I will say to you that I think your second formulation, the present program opportunity notice is far superior to the first one. And the fact that you will not be expecting a recoupment of the investment until profits are actually made as a consequence of the grant being made is far preferable to the first formulation, where you would have been expecting money to be paid back during the course of demonstration of the technology.

So, I join with you in hoping that it works. I still am somewhat skeptical, but I guess time will tell.

Let me ask a couple of other questions along that line. I understand that all proposals to you in response to your program opportunity notice must be received by April 18. At what point in time do you intend to make your first public announcement of the projects that you have reviewed favorably and that you will be commencing negotiations concerning?

Mr. **Bauer**. Two parts to that one, Mr. Congressman. The first one is, in that PON the proposer is requested to provide a publicly releasable statement which we can use in talking about the nature of his response. Once we receive those responses on April 18, as stated, we will put together a release or some type of report, some documentation to tell Congress: Here are the people that have responded, entities, I might say; and here is their public statement.

August 1 is the date for selection for negotiation. So, at that time that would be made available, that the following firms have been selected for negotiation.

Mr. BOUCHER. The administration of the contracts that are awarded by the Department of Energy under the clean coal technology reserve will be in your energy technology centers, as I understand your present plans. If I am right in that assumption, what plans do you have to provide an adequate level of staffing and personnel in the energy technology centers to administer the contracts that are so awarded?

Mr. BAUER. I am going to answer one part and ask Mr. Walsh to address the other one.

Yes; you are correct, Mr. Congressman. The selection for negotiation will be made at headquarters. The negotiation and the execution of those contractual instruments will be done by the Morgantown and Pittsburgh energy technology centers. They will be done in accordance with the lead missions that are now established. Like, Morgantown is responsible for gasification and combustion if there were something there; that's what I mean by that. If Pittsburgh has flue gas cleanup, flue gas cleanup will be Pittsburgh.

Relative to the staff, we have been working. The source evaluation board has had over 50 to 60 people at headquarters as well as representation from Morgantown and Pittsburgh energy technology centers, putting together this solicitation that is on the street. There will be a considerable number from the energy technology center supporting us in the evaluation.

Relative to the number for execution of it, I turn to Mr. Walsh.

Mr. WALSH. All of the activities that Mr. Bauer just said that are ongoing are being done by our in-house personnel that we have on board today. When we finally know the magnitude and the location of where these contracts would be administered, we will be able to then precisely determine the number of additional people that will be required. But at this stage of the game, we are just in some very preliminary planning.

Mr. BOUCHER. But you are anticipating some additional staffing?

Mr. WALSH. Yes; we are.

Mr. BOUCHER. This means bringing new people into the Department or are you contemplating really shifting individuals around?

Mr. WALSH. It's difficult to answer that at this stage of the game, because the type of people that we would need would be more than likely different than the researchers that we have out at the ETC's today. We would need administrative types, legal, financial types.

Mr. BOUCHER. I for one would be interested in following your progress in that regard. As you make some decisions on staffing with respect to administration of these contracts, you could keep the subcommittee apprised. I would appreciate that.

Mr. WALSH. Yes; we will.

Mr. BOUCHER. Mr. Bauer, I just have one further question of you. I was quite surprised to find that the deferrals that you are recommending of programs and research initiatives which Congress included for funding in fiscal year 1986 were exclusively those that Congress recommended. In looking over your deferral list, I didn't see anything recommended for deferral that the administration had in its budget. Everything that was deferred was that which Congress had recommended on its own.

Do you have any explanation for that?

Mr. Bauer. Mr. Congressman, when we took the budget mark and prepared the fiscal year 1987 budget and looked at the activities that would continue on the basis that we have existing cost shared activities--let's talk about, for example, the EPRI Homer City Clean Coal Technology Program for physical cleaning coal—and several other activities which have tremendous high payoffs. So, there are a significant number continuing. Then when you have a fiscal 1987 budget request, it seemed really unfair to go ahead and say: "OK, let's start those activities that Congress added on in fiscal year 1986, when there's no funding request for fiscal year 1987 for continuation of that."

So, we got the budget, the appropriations on December 19. By the time it's down in the procurement process and does a competitive procurement or something like that, the fiscal year is just about gone. And then there's no money in the fiscal year 1987 budget because it is a balanced budget and complies with the deficit reduction targets. So, it was appropriate to, we thought, to take the congressional add-ons.

I think I understand how you feel about that position.

Mr. Boucher. Well, thank you for the understanding.

I am not sure that I fully comprehend your answer. Let me just say that I find it curious, to say the least, that all of the deferrals were congressional adds and in fact virtually all of the congressional adds were in fact deferred.

I have one parochial question to ask you. I notice that in your statement on your budget request, you say that during the course of fiscal year 1986 you cite as one of the Department's accomplishments the completion of research on microbubble flotation. And yet I understand that you do not have a solicitation outstanding for that work at the present time.

How can you in fiscal year 1986 complete research on microbubble flotation without issuing a solicitation? And what are your plans in that regard?

Mr. Bauer. At the EPRI Homer City facility, where we are doing advanced physical coal cleaning, we selected two contractors for approaches to doing that. As I recall the one process that is being pursued there for which it will be tested in either 1986 or 1987 is a microbubble technology. So, with that being done at an appropriate scale, I believe that facility is—what's the--1 ton per hour, if one is doing research at 1 ton per hour, that is a sufficient scale that I think that one could take the data and the economics and all that and do a scale for commercial application. I think that's an indication of a much larger scale than doing bench scale or laboratory research.

Mr. Boucher. Thank you, Mr. Bauer.

Mr. Fuqua. Mr. Packard.

Mr. Packard. Thank you, Mr. Chairman.

In regard to your deferrals, in your testimony you referred to approximately $65 million in deferrals. What position has your office taken toward ongoing contracts? How will you handle those in regard to the deferrals?

Mr. BAUER. All contracts involving deferrals, all those contracts are funded through March 20.

Mr. PACKARD. So that the deferrals have no effect upon the——

Mr. BAUER. The amount of deferral was the congressional add-on less the money needed to maintain those ongoing contracts until March 20.

Mr. PACKARD. All contracts, though, expire on March 20, as it refers to it, the deferrals?

Mr. BAUER. A point is that a contract has an expiration date. The date that I am talking about is the date that they are funded through. They have money obligated to that contractor and saying you have a contract through *x* period of time, but we are obligating money to you to perform work and/or do a service until March 20.

Mr. PACKARD. On your clean coal research, you indicate that you are implementing a cost-sharing arrangement, 50 percent cost sharing. Is that cost sharing or that portion coming from the private sector in addition to the stated amounts that you have under your budget proposal, $397.6 million, of previously appropriated funds? And that's divided down into a yearly basis.

Are those the Government amounts of input into those projects, and we expect a similar amount? Or is that a total amount divided equally?

Mr. BAUER. We expect a similar amount from the private sector in responding.

So, the Clean Coal Program of the $397.1 million, which is the $400 million minus the conferees' reduction of six-tenths of 1 percent, there is some money allowable for administration of that. And also we have to comply with another public law, Small Business and Innovative Research, that will be subtracted off of that. So, when you get down to whatever the Government's share is, we expect an equal share from the private sector. And that could result in almost an $800 million program.

Mr. PACKARD. So, you expect the Clean Coal Program to move at the same level and pace that it was initially designed when we passed the clean coal funding levels last year?

Mr. BAUER. Yes; we do, Mr. Packard.

One of the other things, as mentioned a few moments ago, we expect it to be cost shared on day 1 and all phases equally.

Now, the Government's share is up to 50 percent. The Government's share could be less than that. It depends on what the proposer asks from the Federal Government.

Mr. PACKARD. I certainly hope that the Clean Coal Program can move at the levels that we planned last year, simply because I personally see that as having great potential.

The headquarters program direction, what is that precisely?

Mr. WALSH. The headquarters program direction pays for the salaries and associated costs with headquarters personnel as well as what I would call overhead items, items such as the small business, innovative research, historically black colleges, assessments.

Mr. PACKARD. ETC program direction, would you describe that for me?

Mr. WALSH. ETC program direction covers the indirect personnel costs, which would be overhead-type personnel, budget people, contract administrators——

Mr. **Packard**. So, those two programs essentially deal with personnel and their benefits?

Mr. **Walsh**. Yes; that's correct.

Mr. **Packard**. It's obvious that in that area we have made or you are recommending cuts of about 20 to 27 percent in those two programs, versus the 60-, 70-, 80-percent cuts, 86 percent in the coal gasification area, a significant difference. Could you explain why you are retaining the levels of management and directional or personnel levels in the Department, versus the program cuts, the significant difference in those two cuts?

Mr. **Walsh**. As a member of Fossil Energy, I really didn't think that we were maintaining our levels of personnel. Our level of personnel today is approximately 700 people on the R&D side, both headquarters and field. We are requesting 539, which is a reduction of about 161 actual people. So, that is why we went down by over $15 million in our request for program direction from 1986 to 1987. But it is supporting 539 people in 1987 both the headquarters and the field.

Mr. **Packard**. I am sorry. I guess I am over my 5-minute limit, Mr. Chairman. That went much faster than I expected.

Let me ask one other question. Which projects that you have listed for reductions are being closed down before we have achieved our objectives when we started those projects? Or even the reductions that are at levels that essentially close off an opportunity to reach the objectives that we initially established?

Mr. **Bauer**. Your first question, those being closed down, to my knowledge, none of those projects are being closed down. I am continuing to fund those ongoing projects. The impact of Gramm-Rudman was very, very slight. I think it was like $14 million in the total fossil budget, but there was nothing serious that affected any of those programs.

We are continuing to fund all of those programs, however, there is one program where Congress told us to go pursue a program in accordance with a 1984 program plan. We have not done that because at the present time the money is up for deferral; and that is the MHD Program. We're continuing to fund the contracts but not pursuing the program as stated in the conference report language of 1986.

Mr. **Packard**. Do we see the private sector picking up the slack in any of these projects? We're obviously not reaching all of our objectives in these projects. I have to feel that, were there not a Gramm-Rudman, were there sufficient funds to continue these projects at projected levels or planned levels, we would not be seeing the 60-, 70-, and 80-percent cuts in the programs. I simply would like to know, is the private sector picking up some of this slack? Or are we simply sacrificing some of the objectives of the projects?

Mr. **Bauer**. Again, I don't see the sacrificing of objectives. For example, Wilsonville, which runs at about $600,000 or $700,000 a month, we are continuing to fund that program at that rate. So, I don't see where—we haven't sacrificed, or none of those contracts have been closed down. We are continuing on with them.

One of the things that may be said or is obvious about it is the uncertainty. But the fact is we're continuing to fund those contracts. And it is a budget request. It is a budget proposal to Congress relative to those deferrals, awaiting action on that.

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. FUQUA. Mr. McCurdy.

Mr. MCCURDY. Thank you, Mr. Chairman.

Mr. Bauer, I want to focus for a few minutes on the petroleum research portion of this fossil energy budget, what there is left of it. Some of us on this panel are very disturbed by the program direction that's being charted by the Department. The lower 48 States continue to experience a dramatic drop in oil prices and production. Much of this decline is in the key-producing States represented by a number of members on this panel: New Mexico, Texas, my own State of Oklahoma, and Illinois.

Should this trend continue, many of those States are going to be out of the oil business. That disturbs us greatly because I think the Saudis are more than willing to pick up the slack, which I think is going to affect our national security and our energy security.

As a matter of record, I thought it was very interesting, I was going to ask you: Do you know what portion of the trade balance is made up of oil imports, just off the top of your head?

Mr. BAUER. No; I don't.

Mr. MCCURDY. It's over 5 million barrels per day, $62.6 billion of the $123 billion trade deficit last year; $62.6 billion of the trade deficit is attributable to imported oil. The next highest was $22 billion for auto imports. And you hear all of the clamor out there about auto imports. Where's the clamor about the oil imports? It's $62 billion.

With this continuing decline in production in our States, I think there is only one way—there are a number of ways, but one of the most important ways of improving our own domestic energy security is by improving our enhanced oil recovery. Then the EOR portion of the budget research drops from $11.7 to $4.4 billion in this year's budget. I think that's outrageous. I think it's going to have to change in the priorities.

If we were in Oklahoma, we would call that drilling a dry hole. You know, we're going to have to look somewhere else. We're going to have to change the priorities within that budget.

I also want to ask you a question about the—first of all, why don't you give me an indication of where you think the priorities are on enhanced oil recovery? Is that a necessary function of the Federal Government, in your mind?

Mr. BAUER. Well, two points in response to that. You were talking about the dropping oil prices and the impact on the States and associated matters on that. I guess I believe that, while the present and the near-term price of oil has dropped—and I do not know where it's going to bottom out at. This morning I think it was listed at $12.27 a barrel. The projection is that the world oil prices will begin to resume an upward trend in the nineties.

Mr. MCCURDY. In the nineties?

Mr. BAUER. The nineties.

The fossil program, the way it is structured now, focuses on the long-term basic and applied research needed to make technologies economically competitive. And the current oil price situation, I don't see that as necessitating a restructuring of the program.

The second point is that there is a lot of commercially available EOR technology available. Another part of the fossil program that's under me is the naval petroleum reserve. And we are doing and utilizing the advances made out of the fossil basic R&D program by incorporating some of those enhanced oil recovery techniques up in NPR 1 at Elk Hills and Teapot Dome at NPR 3.

The usage of a fuel—or another way to say it—total energy use tied to research funding is not necessarily a way to determine one's financial needs.

Mr. McCurdy. Well, it's not just purely the basis of financial need; you're talking about long-term planning. You're talking about long-term production. And with the declining production on top of the declining price, quite frankly, we're going to be out of the oil business in the lower 48 States. And I don't see a great clamor on the part of the coastal States to open up their areas.

Mr. Bauer. I don't either.

Mr. McCurdy. So, it's a question of where are you going to invest? There are some, I think, 300 billion barrels of reserve potential that has been abandoned or yet to be extracted from existing wells. So, we're talking about a very minor—you're talking about $4 million in research, and you're talking about a $62 billion problem. You're talking about in the State of Oklahoma alone, the revenue loss by the drop in oil is $467 million this year to one State. In Texas, my friends could probably elaborate on that.

You're talking about $4 million to help long-term stabilization in an industry in developing research? I mean, my God, that's an outrageous position for this Government to be taking.

One last question, and that is that the oil and gas, tar sands, and oil shale extraction are all closely related technologies. Why is the management of these programs spread among so many different locations? The vast majority of tar sands and unconventional gas and high grade oil shale lies in the West. Why are these programs being managed by the eastern center, which has coal as its principal priority? Why not consolidate all these programs near the resources in ways that can exploit the technological energies, or synergies?

Mr. Bauer. When the Grand Forks and the—but specifically talking about the oil shale and the tar sands. When those energy technology centers were defederalized, there was established a project office therefor to assist the new entity—in the case of Laramie, it was the Western Research Institute—in the transition from Federal to private work on a cost-shared basis. That project office was left there with 10 people in it, there was a need for that office to have administrative support as well as for headquarters to have a way of providing policy and guidance and direction. So, the policy and guidance and direction on any technology comes from headquarters. The field then implements that guidance and technology, guidance and direction.

So, there was no place to do that. You can't go straight to a project office. So, what we did was to have those two field offices report to Morgantown, because Morgantown had, if you will, the right kinds of technology people, the procurement, and the personnel to support those project offices.

We have lined up the two ETC's to———

Mr. McCurdy. But I am concerned they don't share the priority. I think Morgantown is building a pretty good empire over there in coal.

Let me just finish with—let me just show you two headlines, OK?

Mr. Bauer. Yes, sir.

Mr. McCurdy. If you can't see them, I will read them for you. This statement says: "White House Abandons Goal of Energy Self-Sufficiency, U.S. to Depend on Arab Oil"; "Saudi Sees Arab Oil as Political Weapon by 1987."

Those are great headlines. Those are very encouraging for those of us in the Southwest. At least the New York Times finally came out and said make OPEC pay our debt. That's the only reasonable thing I have heard them say in a long time.

Mr. Fuqua. Mr. Barton.

Mr. Barton. Thank you, Mr. Chairman.

You are going to get the one-two punch here, Mr. Bauer. We have heard from Oklahoma. Now you're going to hear from Texas.

I lend my support to my colleague from Oklahoma's comments on the oil and gas industry. If you look at the price of oil 3 months ago, it was $27 to $31 a barrel, somewhere in that range. Today on the spot market, West Texas Intermediate last week was $12.68. Contract prices are below $20 a barrel.

If you take the spot market as the price indicator, that is a decline of around 60 percent. If automobile prices had declined 60 percent in 3 months, I think Congress would be up in arms. If steel prices had declined 60 percent in 3 months, farm product prices, you take any basic industry in this country and if the price decline had been that dramatic in that short of a time period, I think we would be working overtime here in the Congress and with the President to try to do something about it.

Yet, because there is a short-term payoff to lower oil prices, we get a 1-percent inflation benefit; so, instead of having 4 percent inflation, we're going to have 3 percent inflation. We seem to think we shouldn't do anything about it. But I am as concerned as Congressman McCurdy that 5 years from now or 3 years from now, when the market has tightened back up and prices start going back up, we will not have a domestic exploration industry. You can't mothball your geologists, your geoscience, your service industries; they're gone.

I was born in 1949. In 1948 the Arab OPEC countries had their first oil supply disruption. Since 1948 they have tried to hold us blackmail five times. So, there's a pattern.

In the oil and gas markets, especially in the oil market, we're not competing in a free market environment against even multinational companies. We're competing against nations. And we're competing against nations which use oil as a weapon of diplomacy. So, when one looks at this budget, this fossil energy budget, and I know that belts have to be tightened; there's no question about that. I have the reputation on this committee as one of the tightest belt tighteners there is. But to see the entire fossil energy budget go from $349 to $150 million over a 2-year period, to see petroleum go from $31 to $10 million over a 2-year period, we're walking away. I don't think there's any other conviction that one could get from that.

I guess my question to you is, Does that seem to be, in your opinion, a good statement of our national policy, that we should just throw up our hands and wave the white flag and walk away from it? What is your reaction to that?

Mr. **Bauer**. Several points you made in your statement. The first one is, talking about the Arab and the OPEC countries. I believe that our imports today being like 5 million barrels that it is, I think there's only like 9 percent that is coming from Arab OPEC countries. The rest is coming from Mexico, Venezuela, Canada——

Mr. **Barton**. It's still being imported. You don't question that?

Mr. **Bauer**. I do not question that.

The next one is, if we look at—going back to some other earlier comments, in oil shale, talking about oil shale and tar sands, there are several technologies that are available today that can make use of that resource. But there are problems with the economics of those processes. There are problems with the environmental aspects of it, as evidenced by the applications that were over at the SFC. Some of those technologies even had their birth in fossil energy.

If you look at EOR, the work that we have done at the universities and doing at NPR and that we're doing out in the field, trying to develop enhanced oil recovery techniques that recover what's left in the ground by the primary process, but then you have to go to secondary and tertiary processes.

When we sat down and looked at where we're at on oil shale, underground coal gasification, and EOR and all of those, and said: what is it that we need to do next, particularly in those times of tight budget times? What we decided was that we were going to put together what I mentioned earlier, the cooperative venture pool, where we say that we are going to go out. We're going to be talking to the marketplace. And we have. The Deputy Assistant Secretary has been contacted by many firms since we made that announcement, and said that we're going to put out criteria for participation in that. Like, he's going to come forward with two partners, significantly less than 50 percent cost sharing. And we'll share in the profits in proportion to the contribution. That includes the revenues and royalties and all that.

But it's a way of them telling us what needs to be done. Now, not all of those that come in will necessarily be selected, because we have to take a look at the national policy and the priorities and the criteria for doing one of those. But it allows more than one company to get together that has ownership, if you will, in a resource. If there were three of us that had an oil shale resource and something needs to be done to bring that cost down, or how better can we dispose of it in an environmentally acceptable manner that spent shale? It allows them to get together.

I think if you got two or three or four—it has to be a minimum of two—four companies together and the Federal dollars, and we are here as a minority partner, it really helps them.

What I am really saying is, that initiative is going to allow the private sector a greater role in establishing the R&D priority and what needs to be done.

Mr. **Barton**. Mr. Chairman, I would like one more question. It will be short. I know my time has expired.

I do want to commend you on the R&D proposal. I think that's good. I don't want you to think that everything you're doing meets with at least this Congressman's disapproval. I think that's a good way to get DOE as a minority partner and work with the private sector.

I may be incorrect in this, but I am told by knowledgeable people in the oil and gas industry that between one-half and two-thirds of all of the oil and gas that have ever been discovered is still in the ground. If that's true, we should be, I think, expending a lot more than $4.4 million on enhanced oil recovery. We should be spending a lot more than $5.2 million on unconventional gas recovery, because the potential payoff there is tremendous.

I am also told that approximately one-third of our domestic production comes from stripper wells. If that's the case, some money spent on R&D in that area could have a tremendous payoff.

I know the budget situation is tight, and I know you've got a tough job. But I am hopeful that this committee is not going to go along lockstep with the priorities that have been given here, because it's tough times out in the oil and gas patch.

You talk about working with the private sector. There is not as large a private sector out there as there was a year ago. Another year from now, it's going to be even smaller.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Barton.

Mr. Stallings.

Mr. **Stallings**. Thank you, Mr. Chairman.

You mentioned earlier in a response to Mr. McCurdy that you see the price of oil going back up in the early nineties. Your best estimate, where are we going to see the price of oil by the end of this century?

Mr. **Bauer**. I think it will go back up into the middle twenties.

Mr. **Stallings**. Do you think it will level——

Mr. **Bauer**. Twenty-five, twenty-eight.

Mr. **Stallings**. You don't think it will be as high as it was in the seventies, or when we went through the oil embargo, when it got up into the thirties?

Mr. **Bauer**. I don't believe so. That's my personal opinion.

Mr. **Stallings**. If when it starts to go the other direction, will we be in a position to handle that kind of increase? Will this budget—I guess what I am asking—will this budget strengthen our own domestic energy sources to the point where they will be usable? Or will there be a domestic energy option for us at that point?

Mr. **Bauer**. Several points on that. What Mr. Barton was talking about a while ago on the oil fields, I guess I come down to the position that there are several enhanced oil recovery techniques and technologies that are available today to go after the oil that is left in the ground after the basic recovery process. We have been working on that for a number of years. The NPR will continue to work on that.

We are using it at the naval petroleum reserve. I read some articles the other day where some companies in California are using it.

I guess looking down through that menu or suite of technologies available, that was one of the reasons for doing this cooperative venture, because we really need to know what else needs to be done to help the people get to that resource so that, when the time comes—and God forbid, I don't want to see it again, the gas lines and all that. But when it does, the marketplace is able to access or get access to and utilize all the resources: the tar sands, the oil shale, the oil in the ground, and the coal.

I think that the initiative of the Clean Coal Technology Program, fiscal year 1986, fiscal year 1987, fiscal year 1988, the congressionally mandated initiative, I don't know what projects are going to be selected; but it says for all markets and all coals. I would hope that—well, not hope. It's saying in there that the purpose of that is to establish the feasibility for the marketplace to act.

The third point is that the coal program, the technology base program is to address the basic technological issues associated with coal, the environment and the economics.

So, that looks like the things that are coming for the nineties. I would hope that all of the programs, the past efforts and the path we're on today will lead to the marketplace having those answers needed to use that resource.

And if we're not doing anything that the marketplace wants—I think we get something like 30 or 40 unsolicited proposals a month. Somebody comes in and says: I got a new idea on coal, or oil, or gas. We review those proposals.

Mr. **STALLINGS**. As I see the role of the Department, it was to establish long-term energy policy for this country, long term, I would think, into the nineties, into the next century.

Mr. **BAUER**. Yes.

Mr. **STALLINGS**. And yet I see a very immediate-oriented policy coming out with this particular budget. It seems to me that we are getting budgeted by the OMB rather than by the needs of the next decade and perhaps the next century. That disturbs me. I feel that particularly in coal research, of which they are doing a certain amount at our national labs. I see that budget being taken apart. I see the alternate fuels essentially falling on hard times.

It seems to me that, when we come to another crisis, we are going to be right back in the same situation that we were in the seventies, without any real alternatives. I am concerned that we are not learning from our past experiences. We seem to react to crises rather than to think into the future and to do things that this Government ought to be doing to prevent those kinds of crises.

I would prefer that we sit down, looking at long-term needs of this country and saying: How best can we use those tight dollars, rather than try to accommodate some short-term results of perhaps 1 percent lower inflation or cheap oil from abroad, without any real long-term concern.

Thank you, Mr. Chairman.

Mr. **FUQUA**. Thank you, Mr. Stallings.

Mr. Walgren.

Mr. **WALGREN**. Thank you, Mr. Chairman.

I would just like to echo and follow along the thrust of Mr. Stallings' line. We do seem to be getting government-by-OMB. It's very hard for us to chart a long-term course unless we can get at what judgments might best be made from the administration's perspective, not just that of the President but also those that have a much more direct involvement and hands-on range of appreciation as well.

Along that line, I wanted to ask the degree of appreciation of stability in this area from the Department's perspective as opposed to OMB's perspective. What we have seen is, we've seen the major reductions of the 1980-82 period, but then the Congress and administration have gotten on to a level of agreement where we have hit consistently, 1983, 1984, 1985, 1986, very closely in terms of the amounts budgeted in each year.

We went from $731 million in 1981, but in 1983 we're at $230 million. In 1984 we are $234 million. In 1985 we were at $252 million. In 1986 we were at $246 million. There is a real stability in those numbers.

I would like to ask if you would give us an assessment of the value of that stability in view of trying to keep a research and development operation intact.

Mr. BAUER. I don't have any disagreement, Congressman, with the numbers you quoted for those fiscal years, which allowed fossil to develop program plans and project plans for carrying out technically defensible, a balanced program. The chairman's question earlier—and you referenced an OMB budget—but that was back in September. It was subsequent to that that there was the Gramm-Rudman-Hollings and the needs to have budget tightening and a balanced budget. So, what——

Mr. WALGREN. Let me stop you there and ask. Gramm-Rudman did not interfere with the stability, or need not interfere with the stability. Fossil can make its contribution without being disemboweled on the floor.

Mr. BAUER. And fossil is making its contribution. The total coal program for fiscal year 1987 budget request is $232 million, with the clean coal and the coal R&D program. So, that's $232 million.

Mr. WALGREN. With the clean coal included. But the clean coal is really something that came along quite independently of the normal fossil fuel research and development budgets. And if you blend that in, you simply have to stop doing most of the things that the fossil research was doing prior to 1987.

Mr. BAUER. But there's still a lot of coal R&D and technology efforts that are continuing on for fiscal year 1986 and fiscal year 1987.

Mr. WALGREN. I guess what I am wondering is, when you take the position that the clean coal thing has to be included in that, and then you reach for the same number as last year or something in that vicinity, if two parties are doing—one party's involved in the Clean Coal Program, and the other party's involved in PETC or METC or the whole range of the Federal Government's ongoing R&D, and you say you're only going to fund it at the same level you did the last year, including this new activity, that means you unhorse fully 50 percent or 60 percent of the ongoing activities that the Department of Energy had been involved in.

Does that serve the cause of stability and attracting the long-term good researchers that you indicate we have to have committed to our Government research institutions?

I gather the answer is no.

Let me ask you one other question.

Mr. **Bauer**. But the amount of in-house research, the two energy technologies, remains fairly constant as a result of this action.

The funding at the national labs and the universities go down, but I believe that the energy technologies is about the same.

Mr. **Walgren**. Let me ask, this difference between the OMB, the role of the OMB, it's our understanding that the Department asked for an R&D program in the range of $270-some million in fossil, I gather. And that then comes back from OMB at something, about $150 million, absent $120 million. Also, in that were the range of deferrals of the things that the Congress had added in the previous budget.

Could you submit to us the request of the Department to OMB so that we could see what congressionally added initiatives were supported in the Department level's budget? It's apparently clear that, unless we have at least a willing partner, nothing happens; and you can't force a horse to drink water. It would be very helpful for us if we knew in those submissions that you made to OMB what congressional adds passed your judgment of what was very recommendable in spending, so that we might then focus our support on those programs which at least have the knowledgeable part of the administration running with us.

Mr. **Bauer**. I will take that request back, Mr. Congressman.

[The information, "Non-Nuclear Energy Research and Development Cooperative R&D Venture Initiative," appears in additional questions and answers for the record.]

Mr. **Walgren**. Thank you very much, Mr. Chairman.

Mr. **Packard**. Mr. Chairman, would you mind if I just pursued one question that I didn't pursue far enough?

Mr. **Fuqua**. Fine.

Mr. **Packard**. I have a little problem with your prioritizing. I recognize the difficult job you have of meeting Gramm-Rudman and meeting the administration's budget priorities. And I support that concept; I have all along. I don't necessarily agree with my two brethren from the oil-producing States. I am also from an oil-producing State, but I also believe there needs to be a balance in cuts, if there are going to be cuts to the levels there are, in the oil research as well as there is in coal and other alternative energy sources. I recognize that.

I have to come back, however, to the problem that I still see and didn't get an adequate response. And that's in the management or in the bureaucracy itself, the personnel area.

I go back 2 years, not just 1 year. I see where there was a 62-percent increase in the headquarters program direction from 1985 to 1986, a 62-percent increase in personnel and benefits, and now about a 20-percent decrease from the 1986 to the 1987 budget year. Well, that adds up still from a 2-year perspective, that adds up to about a 36-percent increase in the bureaucratic structure and costs, at the same time that in that 2-year period we are looking at a—in fact, we're looking at about almost a 60-percent decrease in program areas.

That distresses me a great deal. I would like an explanation as to why you are preserving the bureaucracy and the perks that go with it, at an increase over the 2-year level of 36 percent and at the same time decreasing almost 60 percent in the program levels over a 2-year period.

Mr. Walsh. The increase that you saw 2 years ago was as a result of us being directed by the Congress to cease taxing the—and that's the term they used—cease taxing the research and development program line items in the budget, to cover overhead type items such as was mentioned earlier, small business, innovative research, historically black, these items that have to be funded, computer support at headquarters. The amount added up to, on an annual basis, approximately $5 million.

The Congress wanted us to cease doing that because a certain—we just went right across the board and taxed everything. And in certain areas where there was a congressional add-on for a specific dollar amount, it took its small percentage to equal, to make up for the $5 million. So, Congress directed us to cease doing that and told us to budget for it.

So, in that year, 2 years ago, we did budget for that. And you saw a jump of $5 million. We did not increase any personnel.

Mr. Packard. Who was picking up the tab before Congress made that——

Mr. Walsh. What was done was, we would actually assess each program a percentage. We would assess liquefaction, gasification, oil shale, et cetera, a percentage to cover indirect costs at headquarters as well as, we used to have to pay our annual bill to the TIC and such things as that that we didn't budget for in line items. Well, 2 years ago we were directed to and we did do line item budgeting and ceased taxing or assessing the research programs.

Mr. Packard. If that issue is factored out of these figures, then how much of a reduction in the headquarters program direction would——

Mr. Walsh. Approximately $5 million.

Mr. Packard. Which would then equal about the same levels of cuts in the other program areas.

Mr. Walsh. Yes.

Mr. Packard. Thank you, Mr. Chairman.

Mr. Fuqua. Mrs. Schneider, do you have any questions?

Mrs. Schneider. No; thank you.

Mr. Fuqua. Mr. Bauer, thank you very much for being here this morning. I think you can tell that we are very concerned about the seemingly disproportionate cuts that fossil fuel is being subjected to, and other parts of the DOE budget. I think we are all willing to take the lumps of the Hollings-Rudman-Gramm Act, but we have, it seems, gone a little further here.

Mr. Bauer. Thank you, Mr. Chairman.

Mr. Fuqua. Thank you very much for being here.

We realize it's not all your fault.

[Additional questions and answers for the record follow:]

Department of Energy
Washington, DC 20585

March 18, 1986

Honorable Don Fuqua
Chairman, Committee on
  Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

On March 4, 1986, Acting Assistant Secretary for Fossil Energy, Donald L. Bauer, testified before the Science and Technology Subcommittee on Energy Development and Applications concerning the FY 1987 budget authorization request for fossil energy research and development.

Following that hearing, you submitted written questions for our response to supplement the record. Enclosed are the answers to those questions, which also have been sent directly to the Committee staff.

If you have any questions, please have your staff call Mike Gilmore or Cathy Hamilton on 252-4277. They will be happy to assist.

Sincerely,

Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosure

POST-HEARING QUESTIONS AND ANSWERS

RELATED TO THE

MARCH 4, 1986 HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

HOUSE SCIENCE AND TECHNOLOGY COMMITTEE

U.S. HOUSE OF REPRESENTATIVES

WITNESS: ACTING ASSISTANT SECRETARY BAUER

QUESTIONS SUBMITTED BY: COMMITTEE MEMBERS

COOPERATIVE R&D VENTURE CONCEPT

Question: Although the "cooperative R&D venture" concept is no better defined in the Fossil Energy program than in the Conservation and Renewable Energy programs, your budget provides $12,500,000 for this initiative. On what basis was that decision made? Indication of favorable reception by industry? If so, by whom? Similarity to existing contracts? If so, which ones?

Answer: The decision to initiate the cooperative R&D venture program was based on the need and opportunity to increase private sector participation in R&D decisionmaking and funding, to leverage DOE R&D funding to the maximum extent possible, and to maximize the likelihood of commercial adoption when a technology proves attractive.

Informal conversations with various industrial representatives suggested, in at least a preliminary fashion, that there would be private sector interest in and favorable reception of the concept of cooperative R&D ventures, but no formal responses were solicited. Companies that have expressed some interest include a number in the oil and gas markets. GRI's testimony provided to the House Committee on Science and Technology expressed clear interest in the venture pool concept. The amount of funds required to initiate a pilot program for extraction technologies was also discussed with industry and government parties before the decision was made to include $12,500,000 for the program.

In addition, some former and current contracts involved projects or programs similar to those that are expected to be proposed in the cooperative R&D venture program. Examples of such projects or programs include:

o The EDS liquefaction program. The program involved fundamental research and modeling and applied research and testing on appropriate pilot scales for technology development. It was originally planned to be cost shared on a 50 percent basis. Currently, it is estimated that the private sector cost sharing was actually in excess of 50 percent (i.e., about 53 percent). The project involved Exxon, Philips Petroleum, Atlantic Richfield, and other companies.

- The FY 1986 "optional" program included in the current DOE cooperative agreement with the National Institute of Petroleum Research (NIPER) is anticipated to involve an industrial contribution in excess of 60 percent for principally oil recovery research.
- The current DOE New Mexico Tech Project in EOR research involves a 60 percent private sector contribution from several companies.
- The DOE Methanol To Gasoline (MTG) Project with Germany involves applied research on a pilot scale with DOE contributing one-third of the costs. The participating companies are Mobil from the U.S. and two German firms.
- There have also been encouraging discussions regarding the Underground Coal Gasification (UCG) Project with the Gas Research Institute (GRI) and Stearns Catalytic in which the industrial contribution would be in excess of 50 percent.

These examples indicate the feasibility of creating partnerships with large private contributors for work at the bench to proof-of-concept scales. The Cooperative R&D Venture Pool proposal, is intended as a mechanism to extend and improve upon such opportunities.

COOPERATIVE VENTURES

Question: What examples can you provide in which two or more competing companies have banned together, providing more than 50 percent of a venture cost, with the Federal Government providing the remainder, and engaged in a basic or applied research program?

Answer: Examples of such projects are provided in the response to the previous question.

PHOSPHORIC ACID FUEL CELLS

Question: Failure to provide support for the phosphoric acid fuel cell program indicates that the Fossil Energy program equates development of the air-cooled and water-cooled systems, placing them in the near-commercialization phase. Please provide justification for this decision.

Answer: The Department recognizes that the air-cooled and water-cooled technologies are not equally well developed in terms of the hardware which has been demonstrated. The water-cooled system has been demonstrated by operating a 4.5 MW (4.8 MW dc) preprototype electric utility power plant and by operating forty-six 40-KW preprototype on-site power plants at the sites of prospective customers. In addition, the Department is continuing development of the 11 MW stack configuration "A" with the International Fuel Cells Corporation (IFC) in FY 1986 and FY 1987 utilizing existing funds. In addition, the competitive procurement for configuration "B" cell stack R&D will be funded using FY 1985 unobligated funds. The developer of the air-cooled concept is currently planning to build and operate a subscale 1.5 MW power plant at its facility. EPRI and individual electric utilities are expected to combine with the developer in building and testing this power plant. This is an interim step in the development of 7.5 MW power plants which are planned by the developer. Initial preliminary design work on such a 7.5 MW power plant was completed in 1985 under an agreement between Southern California Edison and Westinghouse. The Department considers both the water-cooled and air-cooled approaches to have been proven to be technically feasible. Completion of the development and commercialization of these technologies is within the capability of the private sector, if that is considered by the companies involved to be a sound business decision.

FUEL CELLS

Question: You characterize the Molten Carbonate fuel cell operating at approximately 60 percent electrical conversion efficiency. What efficiency do you anticipate for the Solid Oxide fuel cell?

Answer: The projected electrical efficiencies of methane-fueled solid oxide fuel cell power plants are 55-60 percent. For coal-fueled solid oxide fuel cell power plants, the efficiencies are 50-55 percent. Depending on the cogeneration application, up to 70 percent overall efficiency could be obtained through utilization of thermal energy.

UNDERGROUND COAL GASIFICATION

Question: At zero funding for underground coal gasification in FY 1987, how will the Department maintain necessary environmental monitoring of completed experiments?

Answer: The Department plans to maintain environmental monitoring of completed underground coal gasification experiments by utilizing prior year appropriations to fund FY 1987 efforts. These efforts include a limited requirement to monitor ground water in the State of Wyoming. It should be noted that all requirements for monitoring in West Virginia have been completed and the site has been abandoned. Similarly, all requirements in the State of Washington will be met during FY 1986 with the uncovering and removal of the burn zone during strip mine operations.

MAGNETOHYDRODYNAMICS

Question: It is claimed that the Magnetohydrodynamics (MHD) process requires definition for the topping cycle, bottoming cycle, and seed regeneration process. What would such a program cost, what period of time would be required for its completion, and what other activity would be necessary for complete definition of the MHD process?

Answer: The program cost was estimated at approximately $150 million and was to have been completed in about 1990. The activities required for the completion of this program include the design and construction of a prototypical combustor and channel; the implementation of seed regeneration process development; the preparation of a retrofit conceptual design; and the acquisition of an integrating contractor.

EASTERN SHALE

Question: A four-year-old Oak Ridge National Laboratory report assesses the recovery of hydrocarbons and minerals from a single Eastern shale. The report stated that strategic minerals recovery could be an increasingly important incentive for commercial development of this resource. What follow-up has occurred or is planned?

Answer: The potential value of strategic minerals in some eastern oil shales, as well as the need to understand/evaluate environmental control requirements posed by these same minerals, has been recognized from the beginning of the restructured oil shale program. Data on these associated strategic minerals is required and utilized in DOE's development systems analysis capability at the Morgantown Energy Technology Center (METC). METC generated data on detailed characterization of shale samples used in laboratory studies. METC obtains such eastern shale resource data from various State Geologic Survey Agencies, where available, and integrates it into appropriate data bases.

Beneficiation studies are underway in a joint research program involving the University of Alabama and HYCRUDE Corp. Information obtained from these studies will help determine how the strategic minerals partition under physical/chemical beneficiation techniques, i.e., whether the strategic minerals are separated from the upgraded material. The recovery process is expected to also involve potentially significant environmental impacts, which must be examined.

FOSSIL ENERGY BUDGET

Question: How would you restructure the fossil energy budget as the price of oil drops?

Answer: We do not anticipate any significant restructuring of the Fossil Energy budget as the price of oil drops. While the present and expected near-term price of oil has been dropping, it is also recognized that world oil prices will again resume an upward trend in the 1990's. Since the proposed Fossil Energy R&D program focuses on the longer-term basic and applied research needed to produce alternative fuel technologies that will be economically competitive in future applications, the current oil price situation does not suggest to us any specific restructuring of the program as proposed in the FY 1987 budget.

FOSSIL ENERGY BUDGET

Question: The possibility exists that the final FY 1987 budget may not contain the stringent cuts below FY 1986 which you request. What plans do you have to implement a larger budget?

Answer: No specific plans exist for implementation of a larger FY 1987 Fossil Energy R&D budget. We believe the Fossil Energy R&D FY 1987 budget request of $150.1 million is adequate and appropriate for continuing a balanced program of generic and technology base R&D.

DON FUQUA, Florida, Chairman

ROBERT A. ROE, New Jersey
GEORGE E. BROWN, JR., California
JAMES H. SCHEUER, New York
MARILYN LLOYD, Tennessee
TIMOTHY E. WIRTH, Colorado
DOUG WALGREN, Pennsylvania
DAN GLICKMAN, Kansas
ROBERT A. YOUNG, Missouri
HAROLD L. VOLKMER, Missouri
BILL NELSON, Florida
STAN LUNDINE, New York
RALPH M. HALL, Texas
DAVE McCURDY, Oklahoma
NORMAN Y. MINETA, California
MICHAEL A. ANDREWS, Texas
TIM VALENTINE, North Carolina
HARRY M. REID, Nevada
ROBERT G. TORRICELLI, New Jersey
FREDERICK C. BOUCHER, Virginia
TERRY BRUCE, Illinois
RICHARD H. STALLINGS, Idaho
BART GORDON, Tennessee
JAMES A. TRAFICANT, JR., Ohio

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUITE 2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-6371

MANUEL LUJAN, JR., New Mexico
ROBERT S. WALKER, Pennsylvania
F. JAMES SENSENBRENNER, JR., Wisconsin
CLAUDINE SCHNEIDER, Rhode Island
SHERWOOD L. BOEHLERT, New York
TOM LEWIS, Florida
DON RITTER, Pennsylvania
SID W. MORRISON, Washington
RON PACKARD, California
JAN MEYERS, Kansas
ROBERT C. SMITH, New Hampshire
PAUL B. HENRY, Michigan
HARRIS W. FAWELL, Illinois
WILLIAM W. COBEY, JR., North Carolina
JOE BARTON, Texas
D. FRENCH SLAUGHTER, JR., Virginia
DAVID S. MONSON, Utah

HAROLD P. HANSON
Executive Director
ROBERT C. KETCHAM
General Counsel
JOYCE GROSS FREIWALD
Republican Staff Director

March 5, 1986

Donald L. Bauer, Acting Asst.
Secretary for Fossil Energy
U.S. Department of Energy
Washington, DC 20585

Dear Mr. Bauer:

Thank you for your excellent testimony before the Subcommittee on Energy Development and Applications on March 4, 1986. Enclosed are a number of questions that Members of the Subcommittee would like you to answer, in order to supplement the record of the hearing.

We would appreciate your responses to these questions by March 18, 1986. If you have any questions regarding this request, please contact Bill Harvey of the Subcommittee Staff at 202-225-2891.

Sincerely,

Don Fuqua

DON FUQUA
Chairman

DF/Hld
Enclosure

BEST COPY AVAILABLE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Department of Energy (DOE)
FY 1987 Authorization Request for
Fossil Energy

March 4, 1986

Additional Questions for the Record

Donald L. Bauer

1. Although the "cooperative R&D venture" concept is no better defined in the Fossil Energy program than in the Conservation and Renewable Energy programs, your budget provides $12,500,000 for this initiative. On what basis was that decision made? Indication of favorable reception by industry? If so, by whom? Similarity to existing contracts? If so, which ones?

2. What examples can you provide in which two or more competing companies have banded together, providing more than 50 percent of a venture cost, with the Federal Government providing the remainder, and engaged in a basic or applied research program?

3. Failure to provide support for the phosphoric acid fuel cell program indicates that the Fossil Energy program equates development of the air-cooled and water-cooled systems, placing them in the near-commercialization phase. Please provide justification for this decision.

4. You characterize the Molten Carbonate Fuel Cell operating at approximately 60 percent electrical conversion efficiency. What efficiency do you anticipate for the Solid Oxide Fuel Cell?

5. At zero funding for Underground Coal Gasification in FY 1987, how will the Department maintain necessary environmental monitoring of completed experiments?

6. It is claimed that the Magnetohydrodynamics (MHD) process requires definition for the topping cycle, bottoming cycle, and seed regeneration process. What would such a program cost, what period of time would be required for its completion, and what other activity would be necessary for complete definition of the MHD process?

7. A four-year-old Oak Ridge National Laboratory report assesses the recovery of hydrocarbons and minerals from a single Eastern shale. The report stated that strategic minerals recovery could be an increasingly important incentive for commercial development of this resource. What follow-up has occurred or is planned?

8. How would you restructure the Fossil Energy budget as the price of oil drops?

9. The possibility exists that the final FY 1987 budget may not contain the stringent cuts below FY 1986 which you request. What plans do you have to implement a larger budget?

(A-159)

NON-NUCLEAR ENERGY RESEARCH AND DEVELOPMENT
COOPERATIVE R&D VENTURE INITIATIVE

Proposed Budget Policy

The allowance provides for a continued, limited Federal role in support of longer-term high risk R&D that generally supports technology development and commercialization by the private sector. However, a new initiative is proposed for an improved DOE/industry partnership in applied technology development.

- o Basic and cross-cutting research, which is usually done in universities and national labs, will continue to be funded through research grants and contracts directed by the Department.
- o Applied research and development -- the type of work that is usually done by private corporations under contract to DOE -- will be continued, but with a new program delivery mechanism emphasizing cooperative R&D ventures with industry in broad areas of technology base R&D.
- o No funds are provided for product development, demonstrations, or other efforts to manipulate or "push" the market in favor of particular technologies.

Budget Summary					OMB FY87 RECOMMENDATION				
	1986 Pres. Req.	1986 Cong. Action	1987 OMB Target	1987 DOE Req.	DOE Managed Base R&D		Coop. R&D Venture Pool		Total
FOSSIL	241	344*	233	270	90		60		150
SOLAR/RENEWABLES	197	213	205	200	53		55		108
CONSERVATION	141	159*	150	150	41		30		71
TOTAL	579	716	588	620	184	+	145	=	329

* 1986 Senate Interior Bill, as reported by full Committee.

Rationale for Change

- o Unlike basic research, a successful applied technology R&D program requires focusing of such R&D in areas supportive of likely industry commercialization of new or improved products or processes.

- The current programs have not been effective in this regard:
  - It is difficult for a large bureaucracy to centrally select potential future "winners" and "losers" among competing technologies for future industry commercialization.
  - The programs are subjected to large appropriations add-ons for a wide variety of special interest projects.
- The resulting programs lack a strategic focus, and instead have a "little for everyone". This does not result in a good return for the Federal investment.
- Rather than continue to debate program and technology priorities within the Department, the Administration and with the Congress, it is proposed to rely on private cooperative R&D ventures to "target" energy R&D to areas of potential pay-off to industry, which would then be partly supported by Federal investments, and mostly supported by private investments.

Benefits of the Proposed Change

- Relevance of the Research: Currently priorities among technologies and specific R&D objectives within each technology are specified in great detail by the Department. The proposed change would give the private sector a greater role in setting R&D priorities and thus assure greater relevance to the marketplace.
- Technology Transfer: Currently, DOE pursues transfer of government-funded R&D results through reports, seminars and other passive forms of transfer. The proposed change provides an active form of transfer by encouraging potential beneficiaries of the research to become direct participants from the beginning.
- Cost Sharing: Currently DOE seeks cost sharing from individual companies for individual research contracts on a case-by-case basis. The result: an average of about ten percent industry cost sharing on applied R&D. The proposed change would encourage more companies to participate in DOE-supported R&D programs, resulting in greater industry cost-sharing.

- Limiting the Federal Role: Currently, DOE seeks to terminate support for particular technologies once proof-of-concept has been demonstrated. This has been only partially successful. Many companies continue to obtain funds for refinements and improvements to proven concepts (i.e., attempts to make an R&D product marketable). In areas where proprietary information is involved, one company may prove its concept; but other companies must then be funded to prove their competing proprietary design.

  The proposed change would disseminate all R&D results among the participating companies, creating in effect a self-policing mechanism to ensure that Federal role in supporting the R&D is limited to technology base activities that are pre-competitive and not proprietary. Moreover, government funds would be used to strengthen the technology base not merely of a single company, but an entire industry.

- Bridging the Gap Between Basic Research and Commercialization; and Univerities and Industry: Currently, DOE seeks to "bridge the gap" through selective R&D investments in the applied technology area that attempt to build upon the results of more basic research. However, given the inherent problems noted earlier, the results appear spotty at best. The proposed change creates a stronger mechanism for "bridging the gap" by allowing DOE (and its laboratories) as well as universities to participate in cooperative R&D ventures in the applied technologies.

- Cost Effectiveness: In an era of tight fiscal constraint, cooperative R&D ventures are the most cost effective mechanism for generating the maximum return for each R&D dollar spent.

Description -- How Cooperative R&D Ventures Will Work

The allowance for applied R&D funding will not be centrally managed as contract research, but rather will be allocated to one of several large funding pools which will be used to take a minority position in private-sector cooperative R&D partnerships.

- Possible role models for such partnerships include EPRI and GRI in the energy industry, and Microelectronics and Computer Corperation (MCC) & Semiconductor Research Corporation (SRC) in electronics.

- DOE also has some experience with cooperative ventures, such as the paper-industry partnership formed by St. Regis for Conservation R&D, and the Electric Vehicle Development Corporation.

- More general discussions of the varieties of cooperative R&D and their potential contributions have appeared recently in Fortune (Nov. 1985) and Bell Atlantic Quarterly (Winter 1984).

Implementation would occur through a DOE notice of interest in joining cooperative ventures. The notice would indicate broad technology areas that would be eligible for support, such as:

Fossil	Solar	Conservation
Coal-Derived Fuels (Gasifications & Liquefaction)	Solar-Electric	Building & Community Systems
Coal Utilization	Solar Heat	Industrial Conservation
Oil, Gas, & Shale	Renewable Energy	Transportation
	Energy Storage & Distribution	

The cooperative R&D ventures can take many forms. Some may be standing organizations, like EPRI and MCC; others may be projects with a two or three year lifetime. In cases where the private corporations have an equity position in the cooperative venture, DOE would also have equity position proportionate to the Federal share of support. Like all cooperative R&D ventures there are likely to be financial benefits to the participants, in which DOE would share. The corporate partners will naturally want to appropriate as much of that benefit for themselves as they can, which will provide an incentive for them to use DOE participation only to provide funding at the margin.

The Department of Commerce has been promoting cooperative R&D ventures and R&D limited partnerships, and can probably be used as a resource by DOE in defining the range of alternative structures that it will consider. DOE can also draw upon its own experience with EPRI, GRI, and the cooperative R&D venture set up with St. Regis and other paper manufacturers.

As we have seen with the preliminary Clean Coal solicitation, the mere announcement of possible interest can stimulate the formation of cooperative arrangements that sometimes continue even if they do not win immediate Federal funding. The energy field has not shown the degree of interest in cooperative R&D that it could, and this would particularly be of benefit to some industries that have traditionally felt unable to engage in serious R&D.

This strategy for allocating Federal funds for applied R&D will give industry a greater direct influence in setting the applied research agenda. In addition, it will stimulate cooperation within the private sector that should lead to new private research activity as well.

Specific Criteria for Selection of Cooperative R&D Ventures

DOE should not impose narrow constraints on the precise type of legal and financial structures that can compete for DOE participation: the nature of the organization proposed will be evaluated along with the technical and budgetary aspects. Nonetheless, the Department should promulgate some criteria that will serve as guidelines to proposers. These criteria should include:

1. The factor by which Federal funding is being leveraged (in all cases, Federal funds should comprise less than half of the total funding for the venture);

2. The Department's certainty that the support they provide will not be displacing support that would otherwise come from the private sector;

3. The degree to which DOE shares in royalties or other profits from the venture, proportionate to its contribution to the venture;
4. Each partnership must contain at least two companies from the same industry (to ensure that their interest will be in pre-competitive R&D); and

5. Preference should be given to cooperative ventures formed by companies that have previously proven themselves successful in obtaining and managing co-funding from private sources.

It should be understood that funds allocated to one of the cooperative R&D venture pools (e.g., Solar Electric, Coal-derived Fuels, etc.) are not to be subdivided along traditional decision unit lines, either formally or informally. All activities within each pool compete equally with each other for funding, according to the criteria above and others that the Department feels are necessary.

It is expected that DOE will use its available R&D to "tip the balance" in the formation of cooperative R&D ventures as a risk-sharing partner so that the maximum number of partnerships will be formed.

This approach to program delivery is independent of the exact funding levels, it is the intent of this Budget Allowance that the structure will be implemented regardless of the final funding levels available.

Attachment

Allowance Summary for Fossil Energy R&D
($ in Thousands)

	Request*	Tech Base	Cooperative R&D Venture Pool
AR&TD....................	34,277	28,000	N/A
Coal-Derived Fuels Co-op R&D Pool................	--	--	10,000
Liquefaction Tech Base.	23,188	9,291	--
Surface Gasification Tech Base............	16,710	2,348	--
Underground Gasification Tech Base.............	5,500	0	--
Subtotal.............	45,398	11,639	10,000
Coal Utilization Co-op R&D Pool................	--	--	35,000
Control Tech and Coal Preparation Tech Base..	38,748	2,375	--
MHD Close-out...........	4,000	4,000	--
Combustion Sys Tech Base	19,920	0	--
Fuel Cells Tech Base....	10,783	0	--
Heat Engines Tech Base..	17,100	0	--
Subtotal.............	90,551	6,375	35,000
Oil, Gas and Shale Co-op R&D Pool..........	--	--	15,000
Unconventional Gas Recovery Tech Base.....	9,305	0	--
Petroleum Tech Base.....	29,450	3,855	--
Subtotal.............	38,755	3,855	15,000
Program Direction, Construction and Equipment..	63,319	40,000	N/A
Allowance Subtotals...	--	89,869	60,000
Total Allowance.......	272,300	149,869	

---

* Departmental request did not distinguish between Tech Base and industry cooperative R&D funding pools, so request and allowance are not directly comparable except at the subtotal level for each pool.

(B-494)

FY 1987 Budget
Department of Energy
($ in millions)

Appropriation: Interior
Decision Unit: Fossil Energy
Organization: Department of Energy

	Request*	Allow.	Appeal	Rec. Appeal Allow.	Final Appeal Allow.	Description of Allowance	Appeal/Comment
						See attached memos for details.	
AR&TD	34.3	25.0 2.0				Reduce activities in Direct Utilization and Materials and Components that should be booked in non-AR&TD areas, and which are of near-term commercial interest to manufacturers.	
Coal-Derived Fuels							
Co-op R&D Pool	--	10.0				Direct funding allowed for laboratory scale research, with some general reductions. Industrial research and POC projects reduced and aggregated into Cooperative R&D venture pool.	
Liquefaction Tech Base.	23.2	9.3					
Surface Gasification Tech Base	16.7	2.3					
Underground Gasification Tech Base	5.5	0					
Subtotal	45.4	21.6					
Coal Utilization Co-op R&D Pool	--	35.0				MHD termination costs shall be provided. Direct funding allowed for CT&CP laboratory coal chemistry and for some waste management research. POC and commercially-oriented work in all areas reduced and aggregated into cooperative R&D venture pool.	
Control Tech and Coal Prep. Tech Base	38.7	2.4					
MHD Tech Base	4.0	4.0					
Combustion Systems Tech Base	19.9	0					
Fuel Cells Tech Base	10.8	0					
Heat Engine Tech Base	17.1	0					
Subtotal	90.5	41.4					

* Departmental request did not distinguish between Tech Base and industry cooperative R&D funding pools, so request and allowance are not directly comparable except at the subtotal level for each pool.

($ in Millions)

	Request*	Allow.	Appeal	Rec. Appeal Allow.	Final Appeal Allow.	Description of Allowance	Appeal/Comment
Oil, Gas, and Shale Co-op R&D Pool	--	15.0				Direct funding allowed for APT, except no funds for Fuels Testing research, or for RFP for re-studying of old ideas.	
Unconventional Gas Tech Base	9.3	0					
Petroleum and Shale Tech Base	29.5	3.9					
Subtotal	38.8	18.9					
Program Direction, Construction and Equipment	63.3	40.0				Reduction in program requires less program management and fewer indirect salaries. No funds have been provided for TIMP, as it will be funded separately.	
Total Fossil Energy	272.3	149.9**					

---

* Departmental request did not distinguish between Tech Base and industry cooperative R&D funding pools, so request and allowance are not directly comparable except at the subtotal level for each pool.

** Any account level offsets to this program funding level are shown in the main passback spreadsheet supplied to the Controller's Office.

Mr. BAUER. Thank you, Mr. Chairman and members.

Mr. FUQUA. Our next panel of witnesses will be Mr. David Webb, senior vice president of the Gas Research Institute; Mr. George Lawrence, president of the American Gas Association; and Dr. Bernard Lee, president of the Institute of Gas Technology.

Let me again welcome all of you gentlemen. You are not strangers before the subcommittee. You are always welcome. We appreciate your contributions every year. We thank you for being here today.

Mr. Webb, we will begin with you.

STATEMENTS OF DAVID O. WEBB, SENIOR VICE PRESIDENT, POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE; GEORGE H. LAWRENCE, PRESIDENT, AMERICAN GAS ASSOCIATION; AND BERNARD S. LEE, PRESIDENT, INSTITUTE OF GAS TECHNOLOGY

Mr. WEBB. Thank you, Mr. Chairman.

I appreciate the opportunity to appear before you today to discuss the Gas Research Institute's views on the fiscal year 1987 budget recommendations for gas-related research and DOE's fossil program. GRI recognizes the Nation is facing severe Federal budget deficits and supports the need to drastically reduce expenditures as Congress intended when it passed the Gramm-Rudman-Hollings bill.

Therefore, GRI is recommending a $65 million core program for gas-related research in the DOE fossil R&D program. This recommendation is significantly lower than last year's gas industry recommendation and is approximately 25 percent lower than the fiscal year 1986 congressional appropriations of $87 million for these same projects.

Central to the GRI recommendation is that the gas industry through GRI's research program is planning to commit $58 million to associated near-term research in these same areas. Even though GRI is not a Government contractor and does not accept Federal funds, GRI cofunds and coordinates many of its research programs with DOE. Therefore, the actions of Congress on the fiscal year 1986 DOE budget deferrals and the fiscal year 1987 DOE budget request do have a direct impact on the gas industry's research program.

In making our recommendations, we looked at funding shifts that are taking place in DOE. We think it is important to note that the fiscal year 1987 budget request significantly reduces spending for energy R&D, increases spending for DOE defense-related activities. The proposed $12.1 billion DOE budget request assigns $8.2 billion, or two-thirds of the funds, to defense activities. This is an increase of 14 percent for these activities over the current budget.

At the same time, new budget authority for fossil energy R&D is reduced by approximately 70 percent, from $300 million in fiscal year 1986 to only $83 million requested for this year.

To further illustrate this dramatic funding shift, the proposed DOE fiscal year 1987 budget request for the Strategic Defense Initiative Program is $604 million, seven times the new budget authority for the fossil program. This, in my opinion, is not sound national energy policy. If Federal energy R&D funding continues this downward spiral, in a few years the Nation will once again find itself faced with rapidly rising levels of oil imports.

It should be noted that the Nation's oil import bill in 1985, as highlighted by Congressman McCurdy, still exceeded $1 billion per week, and oil imports accounted for 21 percent of our energy consumption.

The urgency and necessity of maintaining a viable Federal R&D program in fossil energy becomes self-evident when we examine where the United States is projected to get the major portion of its energy supplies during the next 25 years. DOE's fiscal year 1987 budget book indicates that in 1984 the United States received 90 percent of its energy from fossil fuel. GRI projections indicate that in the year 2010 the United States will still meet more than 75 percent of its energy needs from oil, gas, and coal. Yet, DOE has proposed to assign less than 1 percent of its fiscal year 1987 new budget authority to fossil energy research.

The long-range impact of an unbalanced energy research policy that essentially ignores fossil fuels R&D is made clear when we examine the future U.S. outlook for liquid fuel. The GRI baseline projection of energy supply and demand assumes that the U.S. primary energy consumption will reach nearly 102 quads in the year 2010, with petroleum contributing 35 percent of this total.

While domestic consumption is increasing, the domestic production of crude oil is expected to decline throughout the projection period to a level of 7.8 million barrels per day in the year 2000, a reduction of nearly 1 million barrels from today's production level. Several major oil companies even project the domestic crude production would decline faster to a level of only 6.5 million barrels per day in 2000. The net result is oil imports of between 9 and 10 million barrels per day.

The impact of low oil prices is dramatized even further when we look at the most recent U.S. rotary rig count. This is the leading indicator of oil and gas drilling activity. It reached its lowest level since October 1973, last week when we only had 1,308 rigs operating in the country. Since at least 40 to 50 percent of the domestic oil and gas production in the year 2000 must come from new reservoirs, this collapse in drilling activity, if it lasts for several years, will result in less domestic production and more oil imports.

Past national energy policy as modified by Congress has stressed and encouraged development of our domestic energy resources and the more efficient use of energy to reduce our dependence on insecure oil imports. A central element of this policy has been congressional initiatives to restore funding for critical long-term fossil energy programs in DOE.

Mr. Chairman, in response to your request for suggestions on the funding recommendations of the entire Fossil Energy Program, I would like to at least give you GRI's suggested program priorities.

GRI would recommend that you consider a total program of approximately $255 million, which is 15 percent less than the fiscal year 1986 appropriation level and 25 percent less than the fiscal year 1986 funding before deferrals. These recommendations are based on the following considerations.

Congress has appropriated $400 million for a clean coal technology program. R&D programs in coal technology and coal preparation, combustion systems, heat engine and surface gasification obviously would receive benefit from this program and funding in those areas could be reduced.

Also, the Synthetic Fuels Corporation funded a significant oil shale program before its demise. Therefore, it seems reasonable to reduce oil shale funding in the 1987 proposal.

Also, I think industry should be challenged to share in the cooperative R&D ventures. This would bring at least one-for-one cofunding from industry for the research.

Finally, the phosphoric acid fuel cell research work, which is heavily cofunded with the gas and electric utilities, should be cofunded by industry on a 50-50 basis, again allowing for some reductions in the fuel cell program.

The one central theme, though, of all these recommendations is that GRI is assuming that Congress would not accept the administration's requested deferrals in 1986. If these deferrals are allowed, then the Fossil Energy Program that we have proposed here is clearly inadequate.

While other people would do it in a different manner, I think this is realistic. It does respond, I think, to our need to increase our funding for our enhanced oil recovery work and unconventional gas. It does restore many of the program areas that wouldn't be assisted by the clean coal technology. The funding level is consistent with previous years, and at the same time it achieves its 15-percent reduction, Mr. Chairman.

Within this fossil program funding proposal, like I have mentioned earlier, we are recommending $65 million for gas-related research.

It should be noted that Congress has recognized the need for gas-related research in the past years and appropriated approximately $85 million for these same programs in each of the past 3 years. Therefore, we are seeking just a continuation of the past years' trends, though at a significantly reduced level.

I would like to discuss three specific program areas, Mr. Chairman, within this recommendation.

Surface coal gasification, we are recommending a total of $18 million. Of particular importance is the development of advanced processes that can use high sulfur eastern coals and coal fines. Further development of the Westinghouse and IGT fluidized bed process is needed, and this would require approximately $9 million in 1987.

In addition, Federal support should be continued on catalyst materials, components and instrumentation research. This again would require about $8 million.

Second, in underground coal gasification, we feel like a budget recommendation of $5 million is essential to complete the ongoing research efforts to verify the CRIP technology, which is ready to be demonstrated in the field. It should be noted that GRI and members of the gas industry are willing to cofund the actual field test part of this program.

Unconventional natural gas, we are recommending $14 million; $7 million of this we would recommend for research into tight sands formation. GRI is proposing to fund $11 million in this same research area for near-term activities. And in the Devonian shale, GRI is recommending $4 million to continue two contract efforts that are managed out of Morgantown Energy Technology Center.

Again, GRI has approximately $7 million devoted to near-term research in these activities.

In fuel cells, Mr. Chairman, we are recommending $18 million for the gas-related research. Congress has recognized the potential of fuel cells in the past by adding $26 million to the DOE fiscal year 1986 budget request. Despite this potential and the clear statement of congressional intent, in fiscal year 1987 DOE proposes a budget of only $5 million and at the same time proposes to defer $22 million of the $26 million Congress added. These deferrals will cause abrupt terminations of major, ongoing, cost-shared research programs.

GRI also believes that the Department of Energy needs to reevaluate its basic energy research program and include an element in this program of geosciences, mainly to look at how we find and exploit our domestic resources of oil and gas. As we said earlier, the DOE budget provides less than 1 percent of all research funding to oil and gas, at the same time oil and gas continue to provide over 60 percent of our total energy. Though it's not part of the Fossil Energy Program per se, GRI is proposing that a geosciences program of approximately $35 million within the budget of DOE's Office of Energy Research Programs, which is approximately $1.8 billion in the budget request, be established in order to find a viable program in geosciences.

Mr. Chairman, in summary, GRI recommends a continuation of past congressional actions. We are recommending a budget of $65 million, which is approximately 25 percent less than last year's appropriations for these same programs. And to balance this, GRI is planning to spend $58 million in near-term research in these same activities.

That concludes my formal statement, Mr. Chairman.

[The prepared statement of David Webb follows:]

STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT
POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE
BEFORE THE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
HOUSE SCIENCE AND TECHNOLOGY COMMITTEE
MARCH 4, 1986

I appreciate the opportunity to appear before you today to present the Gas Research Institute's (GRI) views and FY 1987 budget recommendations for gas-related research in the Department of Energy's (DOE) fossil program. GRI recognizes the severe federal budget deficits the nation is facing and the need to drastically reduce expenditures as Congress intended when it passed the Gramm-Rudman-Hollings bill. Therefore, GRI is recommending a $65 million core program for the gas-related research in the DOE fossil R&D program. This recommendation is significantly lower than last year's gas industry recommendation and is approximately 25 percent lower than the FY 1986 congressional appropriations of $87 million for these projects. Central to GRI's recommendation is that the gas industry through GRI's research program is planning to commit $58 million to associated near-term research in 1987.

GRI is an independent, not-for-profit scientific research organization that plans, manages, and develops financing for a cooperative research and development (R&D) program for the mutual benefit of the gas industry and its present and future customers. The R&D program is implemented through contracts with research organizations, engineering and other professional service firms, universities, energy companies, and manufacturers. Funding for the GRI R&D program is provided primarily through regulated sales of natural gas. An R&D funding unit, approved annually by the FERC, is incorporated into the cost of gas of GRI's 32 interstate pipeline company members. GRI members, subject to appropriate state approvals, also apply a similar charge to their intrastate and direct industrial sales. This funding arrangement enables GRI to conduct a truly comprehensive R&D program at a cost to the typical residential gas customer (in 1985) of about $1.40 per year. Even though GRI is not a government contractor and does not accept federal funds, GRI cofunds and coordinates many of its research programs with DOE; therefore, the actions of Congress on the FY 1986 DOE budget deferrals and the FY 1987 DOE budget request have a direct impact on the gas industry's research program.

DOE FUNDING POLICY SHIFTS

In examining the DOE FY 1987 budget request, it is important to note that it significantly reduces spending for energy R&D and increases spending for DOE defense-related activities. The proposed $12.1 billion DOE budget request assigns $8.2 billion, or two-thirds of the funds, to atomic energy defense activities. This is an increase of 14 percent over the current budget. At the same time, new budget authority for fossil energy R&D is reduced by 73 percent from $312 million in FY 1986 to $83 million next year.

To further illustrate this dramatic funding shift, the proposed DOE FY 1987 budget request for the Strategic Defense Initiative (SDI) program is $604 million--seven times the new budget authority for the fossil program. In fact, the increase in the SDI program of $315 million over the FY 1986 appropriated funding level is almost 4 times greater than the new budget authority requested for fossil energy. This is not sound national policy. If federal energy R&D funding continues this downward spiral, in a few years the nation will once again find itself faced with rapidly rising levels of oil imports because it has not established the necessary technology base to fully develop its domestic fossil energy resources and to use them efficiently. It should be noted that the nation's oil import bill in 1985, although reduced significantly from 1984 levels, was still over $52 billion, and oil imports amounted to 21 percent of consumption. Therefore, terminating ongoing energy R&D programs invites severe problems in meeting future energy demand.

RATIONALE FOR FEDERAL FOSSIL ENERGY R&D

The urgency and necessity of maintaining a viable federal R&D program in fossil energy becomes self-evident when we examine where the U.S. is projected to get the major portion of its energy supplies during the next 25 years. DOE's FY 1987 budget book indicates that in 1984 the U.S. received 90 percent of its energy from fossil fuels. GRI's projections (See Exhibit 1), which are consistent with DOE's, indicate that in the year 2010 the U.S. will meet more than 75 percent of its energy needs with oil, gas, and coal. Yet DOE has proposed to assign less than 1 percent of its FY 1987 new budget authority to fossil energy research. Even when only the energy R&D budget category is considered, less than 5 percent of the requested new budget authority is allocated to fossil energy research. A balanced federal energy policy would establish a reasonable relationship between energy R&D funding and the actual anticipated production and use of U.S. energy resources. The DOE FY 1987 budget request ignores these relationships and does not provide a balanced energy R&D policy. Even with the severe spending reductions proposed for FY 1987 fossil research, to fully fund the reduced programs requires the use of $67 million of fossil R&D funds Congress appropriated just four months ago. The administration's FY 1986 deferrals will result in the termination of programs Congress specifically approved.

DOE Secretary Herrington stated in his testimony before Congress last week that DOE's policy is to ". . . concentrate on longer-term research and development leading to a balanced and mixed energy resource base." Yet the nuclear energy research budget is three times larger than the proposed combined budget authority for the DOE fossil and conservation research programs. National energy policy as modified by Congress has stressed and encouraged development of ample supplies of domestic energy resources and more efficient energy use to reduce the dependence on insecure oil imports. A central element of this policy has been congressional initiatives to restore funding for the fossil research program in DOE. Unfortunately, if the nation is to have a balanced energy program, it will require congressional initiatives again this year.

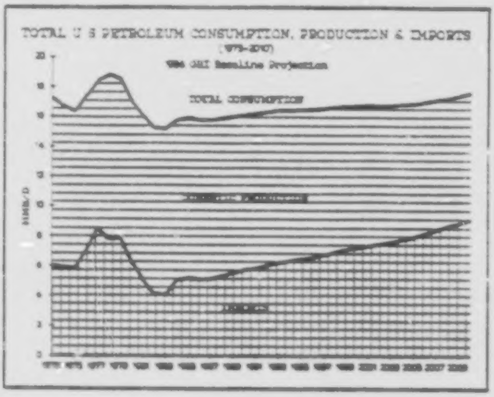
LIQUID FUELS OUTLOOK

The long-range impact of an unbalanced energy research policy that essentially ignores fossil fuels is made clear when you examine the outlook for liquid fuels. A major issue highlighted by the GRI Baseline Projection of U.S. Energy Supply and Demand is the increasing total demand for liquid fuels and oil imports. The GRI Baseline Projection assumes that there will be steady economic growth at average historical rates and no increases in the real dollar-denominated world price of oil and that continued conservation trends will moderate demand growth in all of the energy end-use sectors. Still, it is estimated that U.S primary energy consumption will reach nearly 102 quads in the year 2010, with petroleum contributing 35 percent (36 quads) of the total. By comparison, in 1983 the U.S. consumed 31 quads of petroleum.

Petroleum consumption is forecast to increase from 15.2 million barrels per day in 1983 to 16.7 million barrels per day in 2000. In the extended projection, petroleum consumption reaches 17.6 million barrels per day by 2010. While domestic consumption is increasing, the domestic production of crude is expected to decline throughout the projection to 7.8 million barrels per day in 2000--a reduction of nearly a million barrels per day from today's production levels. The Baseline Projection, when compared to the major oil companies' forecasts, is relatively optimistic concerning U.S. crude oil production. The oil companies expect domestic crude production to decline faster between 1983 and 2000 to around 6.5 million barrels per day in 2000.

The net result of an increasing demand for petroleum with a simultaneous decline in domestic crude production is an increased dependence on foreign sources of crude. The Baseline Projection expects imports to increase to 9.2 million barrels per day in 2010--the greatest demand for imports since the 1977 high of 8.6 million barrels per day. The lower estimates of U.S. crude production from the oil companies would result in even higher levels of imports--over 10 million barrels per day. In fact, if the current world oil price of approximately $15 per barrel is maintained for several years, the amount of domestic oil production probably will be even less than current projections.

This is dramatized by the fact that the most recent U.S. rotary rig count--the leading indicator of oil and gas drilling activity--reached its lowest level since October 1973. Only 1308 rigs are in operation. Since at least 40 to 50 percent of the domestic oil and gas production in 2000 must come from new reservoirs, the collapse in drilling activity, if it lasts for several years, will result in less domestic production and more oil imports.



By the 1990s, the non-OPEC countries will face declining production levels. As a result, the U.S. may be faced with the prospect of again relying on OPEC oil as the major source of its crude oil imports. It seems probable OPEC will require significant premiums in real terms to increase production to these levels which would lead to dramatic escalations in the world price for crude at the turn of the century.

National energy policy as modified by Congress has stressed and encouraged development of ample supplies of domestic energy resources and the more efficient use of energy to reduce the dependence on insecure oil imports. A central element of this policy has been congressional initiatives to restore funding for critical long-term fossil energy research programs in DOE. Maintaining adequate program funding is critical if the U.S. is to successfully develop the full potential of its vast domestic energy resources.

RECOMMENDED DOE FY 1987 FOSSIL ENERGY R&D PROGRAM FUNDING
In response to the Chairman's request for funding recommendations for the entire fossil energy program, I would like to present GRI's suggested program priorities for FY 1987. The realities of the large budget deficits and the Gramm-Rudman-Hollings bill make it imperative to develop the most cost-effective fossil energy program that will fund ongoing critical research projects. In arriving at its recommendations, GRI took the following factors into consideration:

1. Congress has appropriated funds for a $400 million Clean Coal Technology Demonstration Program. Projects funded under this initiative will demonstrate new technologies in the following coal research areas:
   - Control Technology and Coal Preparation
   - Combustion Systems
   - Heat Engines
   - Surface Gasification

   Therefore, significant reductions from the FY 1986 appropriated levels for these program areas are rational. The clean coal funds should be used for advanced technology development.

2. The Synthetic Fuels Corporation funded a significant oil shale program prior to its demise. This federally funded program is continuing. Therefore, a reduction from the FY 1986 appropriated levels for the oil shale program is rational.

3. The phosphoric acid fuel cell research work which is heavily cofunded with the gas and electric industries is advancing to its final stage of development. Therefore, industry should provide 50 percent of the funding to complete the research leading to initial commercial prototype units.

4. GRI assumes Congress will reject the administration's requested FY 1986 deferrals for the fossil energy R&D program. If the deferrals are allowed to take effect, particularly in the fuel cells, surface coal gasification, and MHD program areas, the fossil energy program GRI is proposing for FY 1987 is inadequate.

RECOMMENDED DOE FY 1987 FOSSIL ENERGY R&D PROGRAM FUNDING
($ Millions)

	FY 1986 Appropriations*	FY 1987 Request	GRI FY 1987 Recommendation
COAL			
Control Technology & Coal Preparation	$ 31.95	$ 13.15	$ 18.15
Advanced Research & Technology Dev.	33.85	27.22	27.22
Coal Liquefaction	31.62	9.15	20.00
Combustion Systems	29.11	9.17	14.17
Fuel Cells	34.06	5.00	25.00
Heat Engines	12.31	7.94	7.94
Underground Gasification	4.07	--	5.00
Magnetohydrodynamics	27.72	--	25.00
Surface Gasification	41.32	5.60	18.00
Subtotal	$246.01	$82.23	$160.48

	FY 1986 Appropriations*	FY 1987 Request	GRI FY 1987 Recommendation
PETROLEUM			
Enhanced Oil Recovery	$ 11.45	$ 4.48	$ 10.00
Advanced Process Technology	5.52	1.81	4.00
Oil Shale	12.14	3.60	3.60
Subtotal	$ 29.11	$ 9.89	$ 17.60
GAS			
Unconventional Gas	$ 8.50	$ 5.25	$ 14.00
PROGRAM DIRECTION & PLANT & CAPITAL EQUIPMENT	$ 59.35	$ 40.22	$ 40.22
COOPERATIVE R&D VENTURES POOL	--	12.50	25.00
Subtotal, Fossil Energy R&D	$342.78	$150.09	$257.30
OFFSETS (mainly from prior year's deferrals)	$-46.03	$-67.32	
TOTAL FOSSIL ENERGY R&D	$296.94	$ 82.77	
CLEAN COAL TECHNOLOGY	$ 99.40	$149.10	

---

*Reflects 0.6% across-the-board reductions by conferees.

Assuming deferrals in the FY 1986 program will not take effect, GRI's recommended $257.3 million fossil energy program will maintain a core program for technology development while reducing the budget by approximately 25 percent from FY 1986 appropriated levels. Specific program reductions are based on research funding for projects approved and funded under the authorities of the SFC and the Clean Coal Technology Program.

NEED FOR DOE FUNDING FOR NATURAL GAS R&D

Natural gas will continue to maintain an important role in a highly competitive U.S. energy mix throughout the remainder of the century. (See Exhibit 2.) If funding for a viable federal/gas industry research program is continued, the technology base necessary to develop domestic supplemental gas supplies and more efficient appliances, equipment, and processes to use gas can be established. To develop this technology base requires a 10- to 15-year lead time. The current drop in world oil prices and the natural gas surplus provide a "window of opportunity."

GRI is recommending $65 million for gas-related research in the fossil energy program to fund the technology base. (See Exhibit 3.) Within the fossil energy recommendation is $4 million that could be funded out of the clean coal reserve and $5 million that GRI proposes for cooperative R&D ventures pool funding. In the past four years, Congress has recognized the need for a long-term DOE gas-related program in fossil energy, and it has appropriated approximately $85 million each year for this program. The gas industry is seeking a continuation of this trend in FY 1987 at a reduced level.

GAS RESEARCH INSTITUTE'S 1987 BUDGET

In contrast to the DOE proposal to drastically reduce funding for long-term gas-related research, the gas industry's response to federal R&D policy directing industry to fund more of its own near-term R&D has been very impressive. While DOE has proposed about $22 million--only one-fourth the level of FY 1986 appropriated funds--for FY 1987 gas-related research in the fossil energy program, GRI is planning to increase its own budget for near-term activities in these research areas to $58 million in 1987--more than twice the DOE budget request. Clearly the gas industry has responded to federal energy R&D policy. However, an effective joint effort requires a long-term gas research program in DOE.

RECOMMENDED DOE FY 1987 GAS-RELATED RESEARCH

With the gas industry rapidly increasing its near-term research activities, it is critical for DOE to continue ongoing long-term gas research to have a viable national program. I will discuss important long-term programs in gas research that this Committee previously supported that require continued federal funding.

	FY 1985 Appropriation	FY 1986 Appropriation	GRI FY 1987 Recommendation
Surface Coal Gasification	$31.99M	$41.30M	$18.00M

While the U.S. is currently experiencing a glut in natural gas supplies, in the post-2000 period, GRI projections show gas consumption declining sharply without the development of new supplemental supplies. This would occur because of a reduction in the gas available from lower-48 production. One of the most promising, abundant long-term gas supply resources is the conversion of coal to gas. For coal gasification to have a significant impact, it is necessary to validate the needed economic and design data by the late 1990s.

Of particular importance is the development of advanced processes that can use high-sulfur eastern coals and coal fines. In 1981 GRI and DOE jointly reviewed test results and technical and economic evaluations and decided to concentrate on the further development of the Westinghouse and IGT fluidized-bed processes. Continued federal support in FY 1987 of $9 million is needed for this technology development.

In addition, federal support is needed to continue research programs in improved catalysts, materials, components, and instrumentation. Significant advancements in the economies of coal gasification can result from improvements in downstream processing systems which currently comprise about one-third of the installed plant investment. A viable DOE program requires funding at levels consistent with the past two years' appropriations of $8.5 million.

	FY 1985 Appropriation	FY 1986 Appropriation	GRI FY 1987 Recommendation
Underground Coal Gasification	$5.76M	$4.10M	$5.00M

It is essential to complete the ongoing research efforts in verifying the Controlled Retracting Injection Point (CRIP) concept for underground coal gasification to have an opportunity to make a significant contribution to gas supplies by 2000. The next logical step is to conduct R&D using this CRIP technology in producing gas from a sustained burn in a subbituminous coal seam. In addition, continued technical and economic analysis is required to determine the impact of variations in site parameters such as coal seam depth and thickness, product gas quality, linking technique, facility size, and environmental controls on gas cost. Federal support of $5 million is required. Approximately $1 million of this could be funded from the cooperative ventures R&D pool. GRI and the gas industry have $1.1 million to cofund the cooperative venture elements of this program.

	FY 1985 Appropriation	FY 1986 Appropriation	GRI FY 1987 Recommendation
Unconventional Natural Gas	$10.24M	$8.50M	$14.00M

Current proved gas reserves in the U.S. amount to slightly more than 200 Tcf--only 12 years of supply at today's consumption rate. However, the U.S. Geological Survey estimates that over 600 Tcf of potential U.S. natural gas reserves are still to be discovered. Unconventional gas reservoirs represent one of the best prospects for adding reserves at a competitive cost. Unconventional natural gas refers to gas contained in geologic formations that generally have not been developed by the oil and gas industry due to the cost and difficulty of producing the gas. The National Petroleum Council's (NPC) estimate of an additional 200 Tcf of reserves through development of advanced technology for just the tight lenticular formations and Devonian shales illustrates the potential and rationale for assigning a high federal priority to this research.

The 1987 GRI unconventional natural gas program of $27 million is coordinated with the DOE R&D program. In the "tight sands," so named because they are much less permeable than conventional sandstone, GRI is working on near-term research projects in blanket sands (broad continuous bands of sandstone formed from ocean sediments) while DOE is conducting work in the long-term lenticular sands (individual, lens-shaped deposits imbedded in shale rock).

GRI recommends that DOE continue research in the lenticular formations in tight sands. This research should continue the multiwell test facility activities to determine methods to pinpoint the location and shape of each sand lens and to devise methods for economically extracting the natural gas contained within it. DOE should continue the field laboratory efforts to develop improved diagnostic techniques. This will require $7 million of DOE funds. GRI's 1987 budget for near-term research in tight sands is $11.7 million and concentrates on the blanket sand formations.

DOE should continue research on recovering gas from Devonian shale. These shales are rock formations of organic-rich clay found in nine eastern states. They are typically 200 to 1000 feet thick and lie less than 8000 feet below the surface. The U.S. Geological Survey estimates that between 500 Tcf to 1100 Tcf of natural gas could be contained in the Devonian shales. However, better techniques to fracture the shale and link the shales' natural fracture systems to the wellbore must be developed to allow the gas to flow. DOE funding of $4 million is required in FY 1987 to continue the two contract efforts in recovery efficiency and installation of a reservoir testing facility. METC manages these programs, and they are coordinated with GRI's Devonian shale research which is budgeted at $7.3 million in 1987.

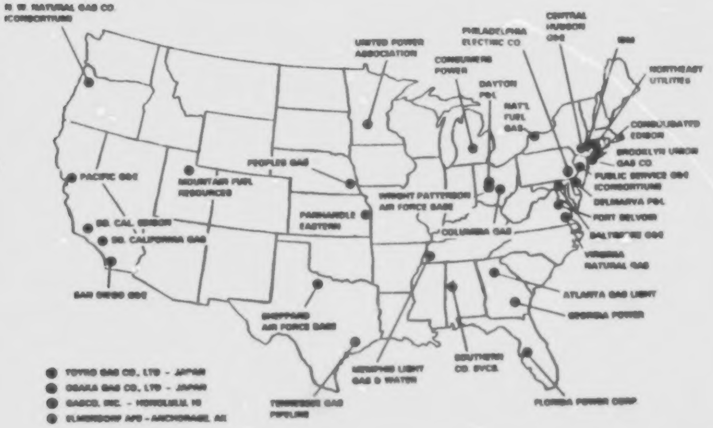
	FY 1985 Appropriation	FY 1986 Appropriation	GRI FY 1987 Recommendation
Fuel Cells (gas-related)	$18.00M	$20.30M	$18.00M

Fuel cell power systems represent a unique approach for supplying both electricity and heating requirements for multifamily residential, commercial, and light-industrial facilities. Congress has recognized this potential by adding $26 million to the DOE FY 1986 budget request. Despite fuel cells' potential and the clear statement of congressional intent, in FY 1987 DOE proposes a budget of only $5 million and also proposes to defer $22 million of the $26 million Congress added. These deferrals will cause abrupt termination of major ongoing cost-shared research projects.

In the GRI/DOE onsite phosphoric acid fuel cell program, Congress appropriated $6 million in FY 1986 that must be funded if the 50-50 cost-shared technology development is to be completed as planned. It is essential that DOE continue its long-term research programs in phosphoric acid fuel cell research. This cost-shared research is only two or three years from a logical conclusion that could result in commercial onsite power systems in the 1989-1991 time frame. GRI proposes $18 million for gas-related fuel cell research in DOE for FY 1987. This includes $4 million for technology-based research on phosphoric acid systems, $10 million for molten carbonate systems, and $4 million for continued work in solid oxide fuel cells. GRI has corresponded with DOE and proposes to cofund the phosphoric acid fuel cell technology base research. This could be funded from the cooperative ventures pool.

In 1982 the gas industry and GRI made a major commitment in funding for onsite phosphoric acid fuel cell systems to offset the loss of DOE funds for near-term research. GRI has now totally assumed the cost of the joint DOE/GRI program to field test the 46 phosphoric acid fuel cell units. Fuel cells were installed in locations throughout the country to test the operational feasibility of the 40 kW power plants in an appropriate mix of actual utility environments. At the end of 1985, all 46 units had been installed in 15 states and had accumulated 420,000 operating hours.

FIELD TEST HOSTS


N. W. NATURAL GAS CO
(CONSORTIUM)
UNITED POWER ASSOCIATION
PHILADELPHIA ELECTRIC CO
CENTRAL HUDSON G&E
CONSUMERS POWER
NORTHEAST UTILITIES
DAYTON P&L
NAT'L FUEL GAS
CONSOLIDATED EDISON
BROOKLYN UNION GAS CO
PEOPLES GAS
PACIFIC G&E
MOUNTAIN FUEL RESOURCES
PUBLIC SERVICE G&E (CONSORTIUM)
WRIGHT PATTERSON AIR FORCE BASE
DELMARVA P&L
PANHANDLE EASTERN
FORT BELVOIR
SO. CAL. EDISON
COLUMBIA GAS
BALTIMORE G&E
SO. CALIFORNIA GAS
VIRGINIA NATURAL GAS
SAN DIEGO G&E
ATLANTA GAS LIGHT
SHEPPARD AIR FORCE BASE
GEORGIA POWER
MEMPHIS LIGHT GAS & WATER
SOUTHERN CO SVCS
TENNESSEE GAS PIPELINE
FLORIDA POWER CORP
● TOHO GAS CO., LTD - JAPAN
● OSAKA GAS CO., LTD - JAPAN
● GASCO, INC. - HONOLULU, HI
● ELMENDORF AFB - ANCHORAGE, AK

A separate four-year technology development program was initiated in late 1982 under a 50-50 cofunded GRI/DOE effort for the purpose of increasing reliability and lowering the costs of these onsite fuel cell systems. The DOE-funded elements of this four-year program require $20 million for this research with the manufacturer, the International Fuel Cells Corporation (IFC). The FY 1987 funding required for the DOE commitment is $4 million. The DOE work concentrates on the fuel cell stack; the fuel processing system, including catalyst research; the inverter; and specialty heat exchangers. The parallel $20 million GRI-funded elements of this four-year joint program concentrate on the near-term aspects of system engineering, coolant system improvements, manufacturing techniques, and improved catalysts.

It is anticipated a commercial offering will be made in late 1986 by IFC to the gas utilities participating in the field tests.

Although phosphoric acid fuel cells show considerable promise for use in commercial, multifamily residential, and light-industrial applications, their use is limited in industrial applications that require higher-quality thermal energy. Advanced fuel cells (solid oxide) can operate at a higher temperature than phosphoric acid fuel cells (1300°F to 2000°F vs. 400°F) and, therefore, can provide higher-quality thermal energy. In addition, advanced fuel cells can achieve electrical efficiencies in the range of 50 to 70 percent. In view of the potential high efficiencies and net fuel savings that will be derived from the development of the solid oxide fuel cell, GRI recommends a budget of $4.0 million for FY 1987 for continued work in solid oxide fuel cells.

Clean Coal Technologies/ Gas-Enhanced Flue-Gas Cleanup	GRI Recommendation $4.00M

GRI is currently working with the Energy and Environmental Research Corporation (EERC) in Irvine, California, and with the EPA to develop a dry sorbent injection technology combined with combustion modification techniques to control SO_x and NO_x emissions from coal combustion. The two developing gas combustion technologies can be applied individually or as an integrated system. One of the more promising SO_x control strategies is to inject calcium-based sorbents into the combustion chamber and capture the sulfur prior to the boiler outlet. GRI's program with EERC is to enhance the cost-effectiveness of this technology through the use of gas combustion technology.

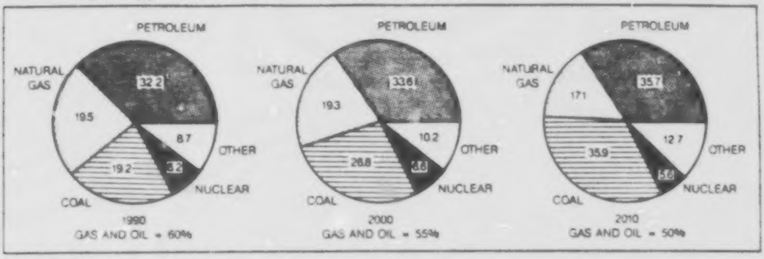
Nitrogen oxide emissions are also considered as a contributing factor to acid deposition. The formation of NO_x during the combustion of fossil fuels can be minimized by appropriate modification of the combustion mixing process. The term "reburning" has been coined in the U.S. to refer to the process of in-house NO_x reduction by downstream injection of gas. When using gas as the reburn fuel, it appears that this technology is capable of reducing NO_x by approximately 50 to 60 percent beyond the current NSPS level achievable with low-NO_x burners.

Over the next two years, GRI plans to spend approximately $5 million to support this research and development. GRI has corresponded with DOE and has indicated if proposals to demonstrate these technologies are submitted in response to the clean coal solicitation, GRI is interested in cofunding.

GEOSCIENCES INITIATIVE

GRI believes that the Department of Energy needs to reevaluate its basic energy research program and take a serious look at a redirection to include an expanded geosciences research initiative. For the next 25 years, GRI estimates that oil and gas will provide over 50 percent of our energy needs. Almost all of the domestic oil production by 2010 will have to come from fields and reservoirs not yet discovered and/or enhanced recovery technologies to produce the nearly two-thirds of the oil currently left in the ground. Whatever is not produced from these domestic discoveries will have to be satisfied by imported oil, primarily from OPEC nations.

U.S. Primary Energy Demand for Oil and Gas Through 2010 (Quadrillion Btu)



Source: 1984 GRI Baseline Projection

Despite this acknowledged demand for oil and gas, the DOE research and development budget continues to address only a small fraction of present and future demand for energy resources. The FY 1987 DOE budget provides less than 1 percent of its funds for all research projects associated with oil and gas, while 1985 consumption of oil and gas was over 60 percent of total U.S. energy consumption, and 2010 consumption will be approximately 50 percent. Therefore, a viable, cost-effective, long-term research program in the high-risk areas of geosciences devoted to understanding the basic geology and chemistry associated with the discovery and production of oil and gas is essential as part of a balanced energy research program.

GRI is proposing a redirection of $35 million within the budget for DOE's Office of Energy Research Programs ($1.74 billion in FY 1986) to establish a viable program in geosciences related to deep-source gas, methane hydrates, geopressured gas, and related generic reservoir phenomena technology.

It is quite apparent that the world and U.S. energy future over at least a 50-year timeframe, and probably much longer, will depend a great deal more on our understanding of geology, geophysics, and geochemistry than on high-energy and nuclear physics and fusion energy. Basic geosciences research would greatly enhance our nation's ability to recover abundant domestic oil and gas. Therefore, DOE should start reordering its priorities without impairing those ongoing activities that are important elements in the nation's energy security by establishing a viable geosciences research program. GRI recommends the following funding profile to establish a viable geosciences program at DOE:

Geopressured Resources	$10.0 million
Methane Hydrates	7.0 million
Deep Source Gas	6.0 million
• Abiogenic Gas	
• Subducted Gas	
Geochemistry/Geomechanics	12.0 million
TOTAL	$35.0 million

Funding Recommendations

INSOFAR AS SPECIFICALLY GAS-RELATED GEOSCIENCE PROGRAMS ARE CONCERNED, GRI RECOMMENDS THAT DOE CONSIDER GREATER INVOLVEMENT IN THE FOLLOWING AREAS

GEOPRESSURED ZONE METHANE
- PHYSICAL/CHEMICAL CHARACTERISTICS OF CONTAINED WATER
- UNDERSTANDING DEEP GAS MIGRATION IN DEEP BRINE FORMATIONS
- TECHNICAL/ENVIRONMENTAL ASPECTS OF BRINE MANAGEMENT
- TECHNOLOGY TO MAXIMIZE METHANE RECOVERY

DEEP GAS
- GEOCHEMICAL/THERMODYNAMIC ASPECTS OF DEEP GAS MIGRATION
- TECHNIQUES FOR DEEP GAS DETECTION
- MODELING MODES OF DEEP GAS ENTRAPMENT

METHANE HYDRATES
- EVALUATION OF RESOURCE POTENTIAL
- IDENTIFICATION OF STRUCTURE GEOCHEMISTRY, ETC.
- CONCEPTUALIZATION OF ECONOMIC RECOVERY TECHNIQUES

GEOCHEMISTRY/GEOMECHANICS
- THERMODYNAMICS OF ROCK-FLUID SYSTEMS
- ROCK FRACTURING/IN-SITU TECTONIC STRESSES
- POROSITY, PERMEABILITY AND DISPERSIVITY OF ROCKS
- HYDROCARBON MATURATION
- CHEMICAL PROSPECTING

SUMMARY

GRI recommends a viable, consistent long-term gas research budget of $65 million (see Exhibit 3) for DOE's fossil program in FY 1987. This funding essentially would continue the programs Congress approved during the past three years. It is consistent with the budget realities resulting from a large federal deficit and the Gramm-Rudman legislation since it is 25 percent less than last year's appropriations for these same programs. To balance the recommended DOE program, GRI's planned 1987 budget for these research areas will be $58 million. (See Exhibit 4.)

These central themes of continued funding for long-term gas research programs in DOE, initiation of cooperative venture R&D with industry, and demonstration of clean coal technologies are sound national energy policies.

Exhibit 1

Table 1. 1985 GRI Baseline Projection of U.S. Primary Energy Consumption (Quads)

	Actual 1984[a]	1990	2000	2010
Petroleum	31.1	32.3	34.6	35.7
Gas[b,c]	17.9	18.3	18.7	16.5
(Total Gas Fuels)[d]	(18.0)	(18.4)	(19.0)	(17.3)
Coal	17.2	19.6	24.9	30.9
Nuclear	3.6	6.4	6.5	5.7
Hydro	3.7	4.0	4.0	4.0
Renewables[e]	4.3	5.1	6.7	9.4
Total	77.8	85.7	95.4	102.2

---

[a] *The March 1985 DOE/EIA Monthly Energy Review (MER) (published June 1985) is used as the source of 1984 historical data. Subsequent MERs included a significant shift in gas consumption from the industrial to the residential/commercial sectors. However, total gas consumption showed almost no change. The 1985 GRI Baseline Projection was based on history and reflects the unrevised data. As a result, the 1984 historical information presented in the tables reflects the earlier estimate of historical data.*

[b] *Excludes synthetic gas from petroleum and coal.*

[c] *Projected gas consumption shown in the table is consistent with the base technology assumption.*

[d] *Total gas fuels includes 0.1, 0.3, and 0.8 quad of synthetic gas from petroleum and coal in 1990, 2000, and 2010, respectively.*

[e] *Includes wood, solar, direct geothermal heat, etc.*

Table 4. 1985 GRI Baseline Projection of U.S. Energy Consumption by Sector (Quads)

	Actual 1984[a]	1990	2000	2010
Residential	9.7[b]	9.9	9.9	10.3
Commercial	5.7[b]	6.6	8.0	9.5
Industrial	24.3	27.8	31.5	32.5
Transportation	19.8	20.2	22.2	22.5
Total Delivered	59.5	64.5	71.6	74.8
Net Losses[c]	18.3	21.2	23.8	27.4
Total Primary	77.8	85.7	95.4	102.2

---

[a] *The March 1985 DOE/EIA Monthly Energy Review (MER) (published June 1985) is used as the source of 1984 historical data. Subsequent MERs included a significant shift in gas consumption from the industrial to the residential/commercial sectors. However, total gas consumption showed almost no change. The 1985 GRI Baseline Projection was based on history and reflects the unrevised data. As a result, the 1984 historical information presented in the tables reflects the earlier estimate of historical data.*

[b] *Historical Energy Information Administration (EIA) statistics for 1984 do not disaggregate data for the residential and commercial sectors.*

[c] *Primarily losses in electric generation and transmission and coal gasification.*

Exhibit 2

Table 2. 1985 GRI Baseline Projection of Gas Demand by Sector (Quads)

	Actual 1984[a]	1990	2000	2010
Residential	4.5	4.3	3.9	3.6
Commercial[b]	2.4	2.8	3.7	4.5
Industrial[b]	7.4	8.2	8.4	6.1
Electric Generation[c]	3.2	2.5	2.1	2.0
Transportation[d]	0.5	0.6	0.9	1.1
Total[e,f]	18.0	18.4	19.0	17.3

---

[a] *The March 1985 DOE/EIA Monthly Energy Review (MER) (published June 1985) is used as the source of 1984 historical data. Subsequent MERs included a significant shift in gas consumption from the industrial to the residential/commercial sectors. However, total gas consumption showed almost no change. The 1985 GRI Baseline Projection was based on history and reflects the unrevised data. As a result, the 1984 historical information presented in the tables reflects the earlier estimate of historical data.*

[b] *Includes gas consumed in commercial and industrial cogeneration.*

[c] *Includes only gas consumed in the utility generation of electricity.*

[d] *Includes 0.3 and 0.5 quad of demand by methane vehicles in 2000 and 2010, respectively.*

[e] *Includes 0.1, 0.3, and 0.8 quad of synthetic gas from petroleum and coal in 1990, 2000, and 2010, respectively.*

[f] *Projected gas consumption shown in the table is consistent with the base technology assumption.*

Table 14. 1985 GRI Baseline Projection of Gas Supply Trends – Advanced Technology (Quads)

	1984	1990	2000	2010
Natural Gas[a]	16.6	16.5	15.1	12.1
Advanced Technology	–	(0.3)	(2.5)	(4.0)
ANGTS Gas	–	–	–	1.2
Pipeline Imports	0.8	1.2	3.1	3.9
LNG Imports	b	0.2	0.7	1.0
Coal Gas	b	b	b	0.3
SNG from Petroleum	0.1	0.1	0.2	0.2
Total Purchases	17.5	18.0	19.1	18.7
Lease and Plant Fuel	1.1	1.0	0.9	0.7
Total Supply	18.6	19.0	20.0	19.4
Less Losses and Exports	0.6	0.6	0.6	0.5
Total Demand	18.0	18.4	19.4	18.9

---

[a] *Includes natural gas consumed in Alaska, lower-48 conventional and unconventional natural gas.*

[b] *Less than 0.05 quad.*

Exhibit 3
RECOMMENDED DOE GAS-RELATED BUDGET FOR FY 1987
FOSSIL ENERGY
($ Millions)

	FY 1987 Recommended	FY 1986 Appropriation
ARTD (Gas-Related)	$ 6.0	$ 12.8
Fuel Cells (Gas-Related)	18.0	20.3
Surface Coal Gasification	18.0	41.3
Unconventional Gas	14.0	8.5
Underground Coal Gasification (Technology Base)	4.0	4.1
Subtotal	$ 60.0	$ 87.0
Gas-Enhanced Flue-Gas Cleanup (Clean Coal Technology Fund)	4.0	N/A
Underground Gasification (Cooperative Ventures Pool)	1.0	N/A
TOTAL	$ 65.0	$ 87.0

Exhibit 4
GRI FUNDING FOR FOSSIL ENERGY RESEARCH
($ Millions)

	GRI 1986 Approved Funding	GRI 1987 Planned Funding
Unconventional Gas	$ 27.1	$ 26.9
Coal Gasification	7.7	4.7
Fuel Cells	5.5	8.4
ARTD	5.2	8.9
Gas-Enhanced Flue-Gas Cleanup	2.6	3.7
Basic Research	4.1	5.5
TOTAL	$ 52.2	$ 58.1

Mr. Fuqua. Thank you, Mr. Webb.

Mr. Lawrence, we will be glad to hear from you.

Mr. Lawrence. Thank you, Mr. Chairman and panel.

I would like to use my time today to support certainly the programmatic outline that Mr. Webb has set forth and that Dr. Lee will discuss, but to move on to a basic change in research philosphy that Mr. Webb alluded to.

It's time for belt tightening. It's time for a lot of research rethinking. There is a lot of gnashing of teeth as a result of the budget limitations that Gramm-Rudman will impose. I think it's a time of opportunity here to really seriously rethink our research priorities.

We have come before this committee and others of the Congress and complained about the electric-related research being something in the range of 17 to 1 over gas-related research. We think that priority is misplaced.

I think the proposal that we will put before you through GRI and through Dr. Lee and which AGA supports is very, very consistent with what the administration's criteria for Federal research is supposed to be, namely, it's high risk. It's successful. It's very high gain. And it does not preempt that which the private sector can do and is doing.

To this end, let me take just a minute to discuss some of the points that I think members of the panel have brought out today. That is, what can we do to improve our own domestic self-sufficiency or less reliance on being held hostage to the OPEC nations, our increasing and even still very high Federal deficit in the form of imported oil? I hark back to the point that it's worth recalling that natural gas is still our largest source of energy produced in this country. It is the largest source used by our residential users, by our commercial users, by our industrial, by our agriculture.

I think we, even in this day and time, we have a restraint on the utilization of natural gas even though we have an oversupply. We still have a bit of the mentality that existed in the mid-1970's when Federal field price controls eventually worked their way, after some 25 years of application, and we ended up with a manmade shortage of natural gas. So, we put restraints on the utilization of gas energy.

We still have the Fuel Use Act that restricts the use of natural gas in industrial applications and some of the most efficient new electric power generation applications. Today the natural gas portion of electric power generation has been reduced to 12 percent. With the removal of the Fuel Use Act restrictions and some of the new efficient applications that would provide a great incentive to our domestic producers today, we could very easily increase that back up to the level of 18 percent, which it enjoyed a few years back.

We look at our resource base of conventional natural gas, and we find something in the range of a 57-year supply of conventional natural gas energy. But when we look to some of the new technology sources, such as the western tight formations, the Devonian shale of the Appalachian East, the free methane and coal seams, we are looking at something in the range of a 200-plus-year supply. New technology has already begun to make some of that move into the commercial mix. New technology could ensure that it would be commercial and ensure a domestic long-term supply.

When I say domestic, also keep in mind that natural gas is 95 percent lower 48 States. The other 5 percent today comes from Canada. So, essentially, it is a domestic fuel, and it certainly is a North American fuel.

Now, if we get into some of the more exotic, research breakthrough potentials, such as the geopressure formation of dissolved methane and the hot dirty saltwater that exists between 12,000 to 15,000 feet in the gulf coastal areas, estimates of 100,000 trillion cubic feet. If as much as a third of that becomes commercially feasible, then we are talking about methane energy or natural gas is our largest source of domestic energy. Now, that's worth devoting research funds and potential and effort toward making it available.

When we talk about gas hydrates, this is methane dissolved in ice fixtures around our coastal areas, we are talking about as much as 2 trillion cubic feet of potential. When we talk about the abiogenic sources of natural gas, it again is truly inexhaustible.

So, this already, 95 percent, total 100 percent North American source of energy, could with research breakthroughs be made inexhaustible; and we could be totally self-reliant in energy. That is a worthy research goal, we submit.

When we talk about utilization and more efficient sources of burning our fossil fuels or other sources of energy, we turn very quickly to some of our environmental concerns. We hear the discussion of acid rain and pollution in our cities. We see the contribution the natural gas can make in the form of select use and more efficient combustion, burning natural gas with coal. We see the contribution that natural gas vehicles could make, particularly in our major urban metropolitan areas. In the programmatic outline here that Mr. Webb and Dr. Lee will discuss, there are several specifics that can make a contribution there.

I will wrap up my part of it by just restating. It is, I think, now that we have this stringent requirement on all Federal expenditures, it is time to make up a lemonade out of this lemon and really seriously reallocate our research priorities and focus on that, which can make our greatest contribution toward domestic energy self-sufficiency and environmental goals.

Thank you.

[The prepared statement of George Lawrence follows:]

TESTIMONY OF GEORGE H. LAWRENCE
PRESIDENT, AMERICAN GAS ASSOCIATION
BEFORE THE
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES
ON THE FY 1987 DEPARTMENT OF ENERGY
RESEARCH AND DEVELOPMENT BUDGET

March 4, 1986

Mr. Chairman and Members of the Subcommittee: I am George H. Lawrence, President of the American Gas Association (A.G.A.). I am pleased to appear before you in support of natural gas-related research and development (R&D) conducted or sponsored by the Department of Energy (DOE).

A.G.A. is a national trade association consisting of nearly 300 natural gas distribution and transmission companies that serve more than 166 million consumers in all 50 states. Collectively, these companies comprise nearly 85 percent of all gas utility sales in the United States.

In recognition of the constraints on Federal spending resulting from Gramm-Rudman-Hollings, the gas industry has reconsidered its priorities for federally-sponsored gas R&D. Accordingly, A.G.A. recommends an authorization of $156 million for all DOE natural gas-related R&D in FY 1987. Our total FY 1987 recommendation reduces by 22 percent A.G.A.'s FY 1986 recommendation of $200 million. We consider this reduced level of funding for gas research in FY 1987 to be the minimal necessary to develop and utilize future natural gas resources to their fullest potential.

DOE FUNDING FOR GAS AND GEOSCIENCES RESEARCH

Natural gas is a vital source of energy for the United States economy. For example, in 1985, estimates indicate that gas accounted for 24 percent of the primary energy consumed in the United States. Indeed, over the past 25 years, natural gas has accounted for between 24 and 33 percent of all of the primary energy consumed in the United States. Natural gas is used throughout all sectors of the economy. In 1985, gas constituted 51 percent of all end use energy consumed in the residential sector of the economy, 43 percent of all end use energy consumed in the commercial sector and 38 percent of all end use energy consumed in the industrial sector. In addition, natural gas accounts for 12 percent of all fossil energy consumed in electricity generation.

Natural gas has positive attributes which will allow it to continue to be a critical source of energy in the future. First, gas supplies are plentiful. The Potential Gas Committee, the industry group that evaluates future gas resources, has estimated that with forseeable technology and economics, the United States has approximately 981 Trillion Cubic Feet (Tcf) or about 57 years of gas supplies from conventional sources. However, many experts contend that the total amount of gas existing in conventional and unconventional geological formations that is currently unrecoverable exceeds 100,000 Tcf. Thus, major breakthroughs in gas recovery technology enabling the recovery of one or two percent of the total gas resource base would result in doubling or tripling our 57 year recoverable gas supply. Second, natural gas is the cleanest of all fossil fuels. Gas combustion emits virtually no sulfur dioxide or particulate matter, and far fewer nitrogen oxides, nonmethane hydrocarbons and carbon monoxide than either coal or oil. Moreover, natural gas combustion does not have disposal problems such as fly ash from coal or spent nuclear fuel. Increasingly, natural gas is becoming recognized as a fuel that can be used without creating substantial environmental hazards. Third, more and more commercial and industrial users are recognizing the benefits of using natural gas. Emerging gas utilization technologies such as commercial gas cooling systems, combined cycle gas turbines, select use of gas, fuel cells and advanced cogeneration systems offer greater fuel efficiencies that will allow commercial and industrial energy users to reduce energy costs.

Although natural gas will be, in the forseeable future, a primary source of energy for the United States economy, the DOE invests relatively few of its research dollars to ensure that gas reserves will meet future gas demand. Research in the geoscientific fields of geology, geophysics and geochemistry is necessary to increase our basic understanding of the formation and recovery of unconventional gas resources. Increased understanding of unconventional gas resources is required to achieve the technological advances that will expand the recoverable gas resource base. Indeed, production from conventional sources of gas located in the Lower-48 States is expected to decline by the year 2000. Thus, increased production from unconventional sources will be necessary to compensate for declining conventional production.

With federal assistance, the gas industry can achieve these technological advances and ultimately improve U.S. energy supply security more quickly and for substantially less money than the DOE nuclear fusion program. Even though billions of dollars have been spent on nuclear fusion research, fusion as a source of energy may not be feasible technologically until well into the 21st century.

In stark contrast, we know that, with a federal commitment of several million dollars, we can achieve technological breakthroughs in gas supply research that will expand significantly the recoverable gas resource base and improve our nation's future supply security. First, the immensity of the total gas resource base (both recoverable and unrecoverable) is well-known and well-documented. Second, recovery of much of the gas located in currently unrecoverable sources of gas is technically possible but economically infeasible. For example, high production costs prevent the recovery of much of the gas located in tight geological formations such as Devonian Shales and tight sands. Research breakthroughs in the techniques for recovering tight formations gas could lower production costs and increase the amount of gas that may be recovered.

To achieve the results in gas supply that we envision, DOE must fund more basic research in the geosciences. DOE currently funds a small geosciences research program within the $450 million Basic Energy Sciences (BES) program. We request that Congress direct DOE to spend, from the $441 million that DOE requests for the BES program in FY 1987, $35 million for basic geosciences research. A well-funded federal geosciences program is strongly supported by the Interstate Oil Compact Commission (IOCC), via an IOCC resolution adopted last December (attached as Exhibit A). These funds would be used not only to conduct long term, high risk geosciences research, but also to train young men and woman in the geosciences field.

Advances in end use utilization of natural gas have already increased the efficiency of gas appliances and processes. Further technological advances in gas utilization will enable a single piece of equipment to provide multiple energy services with significant cost savings and efficiency gains. Further research on electrochemical processes and thermodynamics could radically change the manner in which gas is transformed into usable energy.

Increased gas use can also provide solutions to pressing national energy and environmental problems. Our nation has several energy- related problems: (1) energy security because of oil imports; (2) air pollution resulting from sulfur oxide emissions; and (3) potential shortfalls in electricity generating capacity. The development of new, highly-efficient gas utilization technologies can solve these problems by reducing our dependence on imported oil, reducing sulfur oxide emissions and assisting electric utilities in meeting electricity demand.

SPECIFIC FUNDING RECOMMENDATIONS

UNCONVENTIONAL NATURAL GAS: $14 Million

Large amounts of gas have been identified in tight geological formations such as Devonian shales and tight sands. Devonian shales and tight sands are estimated to contain more than 1,800 Tcf and 900 Tcf of gas, respectively. Tight formations gas is produced using unconventional recovery techniques. A.G.A. estimates that favorable economic conditions and substantial investment in tight formations R&D programs could result in "incremental" production of up to 6.0 Tcf of gas annually by the year 2010, while a lesser technology program would result in an annual production rate of 1.0 Tcf by that year.

To increase production from unconventional gas resources, more research must be conducted to develop advanced stimulation techniques to fracture tight rock formations that restrict gas flow. Current fracturing techniques induce only shallow fractures of a few hundred feet. Field testing must be conducted to refine techniques for inducing deep fractures of several thousand feet. Such techniques include foam, cryogenic, hydraulic, chemical explosive, and high energy gas fracturing. In addition, research information must be collected from field testing to establish a technological database for stimulation modeling, economic modeling and other analytical purposes.

SURFACE COAL GASIFICATION: $18 Million

Surface coal gasification is an important technology that can augment future natural gas supplies. Contemporary technologies allow significant production of gas from coal; however, high production costs have prevented coal gas from becoming a major energy source. Substantial research on advanced gasification processes is necessary for synthesized gas from coal to play a role in meeting this nation's future energy needs. Gasification techniques must be developed to accommodate high-sulfur Eastern coals and combustion-inhibiting coal "fines." Research must be conducted to develop techniques for gasifying these "fines" and liquid byproducts, and for consolidating "fines" and tars for utilization. Scientific and engineering feasibility studies of advanced gasification processes must also be conducted to develop a technological database for such processes. In addition, research must be conducted to identify the proper treatment and disposal techniques for gasification waste byproducts.

GAS-ENHANCED FLUE GAS CLEANUP: $4 Million

Natural gas-enhanced flue gas cleanup, otherwise known as reburn, is a post-combustion pollution control method that can be used to reduce NO_x levels found in the combustion products of coal-fired electric utility or industrial boilers. Natural gas (or another fuel) is injected into the exhaust from a coal-fired boiler, creating a fuel-rich zone in which the NO_x reacts and produces free nitrogen. Air is then added to complete the combustion process. Preliminary testing indicates the reburn process using gas could easily reduce NO_2 emissions by 50 percent.

Research on the reburn process must be conducted to determine: (a) how close the reburning fuel should be relative to the combustion zone; and (b) how much time should be allowed for reburning before air is injected into the process. Funds for this research could be derived from the Clean Coal Technology appropriation.

GEOPRESSURED METHANE: $7 Million

Geopressured methane is found in either a free state or dissolved in water and trapped in sedimentary rock at higher-than-normal pressures. One of the largest geopressured areas underlies a portion of the Texas and Louisiana Gulf Coast. Estimates of the total resource in-place range up to 100,000 Tcf; however, estimates of the amounts of gas that might ultimately be recovered range between 25 and 1,200 Tcf. Given the large in-place resource, geopressured methane could be a virtually inexhaustible source of domestic energy.

Research conducted by the DOE in the geopressured zones is focused on producing both gas and electricity from low-grade heat in the reservoir brine. The DOE should redirect its research efforts and concentrate more on recovering the vast amount of dissolved methane found in geopressured zones. In addition to the DOE's current geopressured program, the DOE should attempt novel approaches that utilize traditional engineering principles to maximize gas production and minimize brine production.

FUEL CELLS: $18 Million

Gas-fired fuel cells, in a highly efficient electrochemical process, convert the energy content of gas directly into electricity and byproduct heat. This process is much more advantageous than current electricity generation technologies, which rely upon the less efficient combustion process to generate electricity. The electrical conversion efficiency of gas-fired fuel cells is approximately one-third greater than the conversion efficiency of traditional electricity generation. Combining fuel cells with cogeneration equipment could achieve combined electrical and thermal conversion efficiency of 80 percent, compared to a conversion efficiency of 36-40 percent by the typical electric utility. Fuel cells are also environmentally benign.

More funding for phosphoric acid fuel cells is necessary for generic technology verification. Improved techniques for controlling phosphoric acid electrolyte and increasing the efficiency of DC to AC power inverters must be achieved. Research must also be conducted to develop second-generation molten carbonate fuel cells capable of processing gases containing sulfur and chlorine, as well as to develop other advanced, direct conversion concepts.

CONSERVATION: $27 Million

(1) Gas Heat Pumps ($10 million)

The operating principle of heat pumps is similar to that of an air conditioner: heat is removed from one source and pumped to its destination. By extracting heat from the outside air and transferring it to indoor space, heat pumps can actually supply more thermal energy than is contained in the fuel that they use. The heat pump's cooling effect is accomplished by reversing this process. The gas heat pump provides heating and cooling in a single unit using less energy than a conventional or high efficiency furnace uses for heating alone. Current performance estimates suggest that in heating, the gas heat pump could save one-half of the gas used in a conventional furnace and one-quarter of the gas used in a high efficiency furnace.

More research is necessary to develop highly-efficient, reliable and cost-effective gas heat pumps for residential and commercial applications. Such research must include the evaluation of promising technical approaches, fundamental research in basic heat pump processes, phenomena and materials, and research on generic component development. These activities must be integrated into overall heat pump system development and analysis. The most promising gas heat pump concepts are the double-effect absorption concept, absorption technology using fluids in novel cycles, and engine driven concepts using available internal combustion technology.

(2) Industrial Cogeneration ($5 Million)

Gas-fired cogeneration can supply both electrical and thermal energy service in a highly efficient manner. The environmental benefits of gas-fired cogeneration are also significant, since the efficient use of clean-burning gas decreases total emissions. A coordinated federal/industry cogeneration research program focusing on cogeneration of electricity or shaft horsepower and useful heat could produce overall efficiencies of 70 to 80 percent. New approaches that meet the combined thermal, shaft horsepower, and electrical requirements of an industrial facility are needed. The major problem is to develop and build advanced systems with improved operating efficiencies and ease of maintenance.

The DOE's research should focus on developing advanced materials and advanced heat transfer, thermodynamic and microprocessor concepts. These components and concepts must then be integrated into prototype units to allow industry to evaluate the effectiveness, efficiency, reliability, and flexibility of cogeneration systems. The result is increased cost savings and expanding potential applications for gas-fired cogeneration systems. Improved components from this DOE-sponsored research can be integrated into both first- and second-generation packaged cogeneration systems.

(3) CNG Vehicles ($2 million)

Broad development of vehicles fueled by compressed natural gas would serve the national interest by improving air quality, since the emissions from CNG vehicles contain only a fraction of the nonmethane hydrocarbons, carbon monoxide, and nitrogen oxide produced by gasoline-powered vehicles. Furthermore, unlike gasoline-powered vehicles, CNG vehicles emit almost no sulfur oxides or particulate matter. Fleet use of CNG vehicles in congested cities would provide a significant benefit to those areas where air quality improvement is most critical.

Fundamental research is necessary to acquire a thorough understanding of the intricacies of gaseous fuel carburetion, manifolding, combustion, power optimization and emissions control so that natural gas can become universally accepted as a transportation fuel. Further research into novel gas compression concepts is necessary to advance the development of compressor technology. Research must also be conducted to increase the understanding of gas storage technology, particularly the fundamental principles of natural gas adsorption, absorption, clathration and catalysis.

UNDERGROUND COAL GASIFICATION: $5 Million

Underground coal gasification is the process whereby coal is burned underground, in formation, generating a low-Btu or medium-Btu gas. The coal is gasified by drilling boreholes into the coal seam, igniting the coal and injecting air or steam and oxygen into the reaction zone. The hot gas is forced through the seam to an exit borehole where it is carried to the surface and processed to remove impurities. The gas can then be used directly as an energy source or can be upgraded to pipeline quality through catalytic methanation.

Over 80 percent of the coal resource-in-place cannot be recovered using conventional mining techniques. Underground coal gasification could increase substantially the amount usable energy that could be recovered from the coal resource base. Moreover, underground coal gasification offers potential environmental, economic and safety advantages over conventional mining.

Extensive field testing is necessary to understand the technological basis for linking the vertical wells through the coal seam and controlling the movement of the reaction zone. Extensive environmental monitoring is also required to analyze and control the potential contamination of surface water and local aquifers (geological formations containing water), and to control surface subsidence.

ADVANCED RESEARCH & TECHNOLOGY DEVELOPMENT: $6 Million

The Advanced Research and Technology Development program generally provides a technology base for ongoing fossil energy projects and for advanced process development. Current research needs include improving the understanding of the interactions of coal gasification processes in a fluidized-bed environment; improving the understanding of the interaction of gasification catalysts with carbon/steam and carbon/hydrogen reactions; developing advanced processes for low-cost synthesized gas; developing lower-cost acid-gas cleanup processes; and continuing efforts to assess advanced cleanup technology for alkali metals, particulates and tars.

LIQUEFIED NATURAL GAS SAFETY: $4 Million

Liquefied natural gas (LNG) is natural gas which is converted into liquid form by reducing its temperature to minus 260°F. This technique is advantageous because it permits large volumes of natural gas to be transported over great distances and terrain not otherwise suitable for pipelines. Potentially, the resource base for LNG includes any overseas gas reserves beyond those required for local consumption. However, one difficulty with transporting LNG has been that virtually no experimental data exists on the behavior of large spills.

The test facility will allow researchers, on a user fee basis, to evaluate spills of liquefied gases, including LNG, at magnitudes far greater than has been previously possible. The research needs include investigating equipment vulnerability to natural forces, the ability of dikes to contain large spills, the advantages of in-ground storage, the behavior of spills on different surfaces and the validation of methods for preventing accidental liquefied gaseous fuels spills.

BIOMASS: $18 Million

Since the supply of organic and waste materials is virtually unlimited, supplemental methane supplies from biomass and waste conversion can add significantly to the total future gas supply picture. Developing energy from biomass also would promote the environmental benefit of productive use of currently "useless" materials. However, the quality of the gas produced and a suitable processing technique are important concerns that inhibit the widespread use of these potential gas resources.

The sources of biomass, land and marine plant matter, must be tested to determine the appropriate technology for producing high-quality gas from the resource. Because these sources vary greatly in content, the technologies must be flexible. To produce gas economically, processing techniques must be improved to increase conversion efficiencies.

CONCLUSION

The natural gas industry recognizes that Gramm-Rudman-Hollings places severe constraints on Federal energy research dollars. Our recommendations for gas research in FY 1987 reflect these concerns. We believe that our recommendations are both necessary and prudent. If Congress adopts the gas research program supported by the gas industry, the nation will be able to bolster U.S. energy supply security and improve energy efficiency.

EXHIBIT A

RESOLUTION
BEFORE THE CONVENTION OF THE
INTERSTATE OIL COMPACT COMMISSION

WHEREAS, The United States is predicted to rely upon oil and natural gas to satisfy approximately 50 percent of its energy demand for the next 25 years, and

WHEREAS, Whatever United States demand for oil cannot be satisfied by domestic production will, in the short-term, be satisfied by imported supplies of oil, and

WHEREAS, Relatively expensive supplemental supplies of natural gas could also be subject to competition from imported oil, thereby leading to even greater dependence on the oil supplies of foreign nations, and

WHEREAS, United States hydrocarbon resources could be used to fill this future demand and thereby reduce the reliance on imported oil, and

WHEREAS, The potential domestic production of oil from non-traditional geologic formations, such as subtle traps, plus the potential additional production from domestic resources if adequate technology for enhanced oil recovery could be developed, could be over 500 billion barrels, and

WHEREAS, Many hundreds of trillion of cubic feet of gas could be recovered from such non-traditional reserves of gas as geopressured reservoirs along the United States Gulf coast, methane hydrates along the Continental Shelf off the North American coast, and from formations much deeper than state of the art drilling technology can reach, and

WHEREAS, The Department of Energy energy R&D budget is seriously imbalanced since it allows only 8.4 percent of its funds for all research projects associated with oil and gas, while 1985 consumption of oil and gas will be over 60 percent of total U.S. energy consumption, and 2010 consumption will be approximately 50 percent,

THEREFORE, The Interstate Oil Compact Commission urges the Department of Energy to promote the use of domestic resources of oil and natural gas to satisfy future demand and at the same time, to correct the severe imbalance between funding priorities in the energy R&D budget and projected United States demand for energy, by shifting sufficient funds within its planned budget to eventually provide for an adequate program in research of geoscientific issues associated with the discovery of oil and gas, amounting to approximately $50 million per year; such a newly established effort would (1) advance the state of the art in these technologies, and (2) through funding at leading universities and other institutions in the field, assure the availability of well-trained professionals in the geoscientific field which will be needed by our country to satisfy the demand for oil and gas, to the maximum extent practicable, from domestic resources.

EXHIBIT A

INTERSTATE OIL COMPACT COMMISSION

HEADQUARTERS OFFICE 900 N. E. 23RD STREET • P. O. BOX 53127 • OKLAHOMA CITY, OKLAHOMA 73152
TELEPHONE (405) 525-3556

Address Reply to Headquarters Office

GEORGE NIGH
Governor of Oklahoma
MARK WHITE
Governor of Texas
Joint Chairman

W. TIMOTHY DOWD
Executive Director

December 9, 1985

Fellow IOCC Members:

The Interstate Oil Compact Commission has long been concerned with the level of federal research support devoted to geoscientific issues associated with the discovery and production of oil and gas. From a 1985 Department of Energy research and development budget of $1,859,600,000, less than $13 million was spent on geoscientific research to enhance oil and gas discovery and production. In comparison, oil and gas resources currently satisfy 60% of U.S. energy needs and are expected to satisfy 50% or more of those needs through the year 2010.

We are all aware of the new oil and gas discoveries which must be made in order to avoid over-reliance on foreign oil supplies. We are also cognizant of just how difficult it will be in the future to discover and produce the new hydrocarbon resources needed, without significant new knowledge and technology in the geosciences. Research targeting such areas as the investigation of subtle traps, new techniques for enhanced recovery, advances in the understanding of nontraditional oil and gas bearing geological formations, and deep source gas theories can help us address these needs.

Passage of the resolution now under consideration will not only demonstrate the oil and gas community's concern for adequate federal research support, but also urges fiscal responsibility through a critical redirection of federal funds (ultimately $50 million per year) rather than adding to the federal budget.

We hope you will join us in this effort.

Mark White
Mark White
Governor of Texas

George Nigh
George Nigh
Governor of Oklahoma

MEMBER STATES: ALABAMA · ALASKA · ARIZONA · ARKANSAS · CALIFORNIA · COLORADO · FLORIDA · ILLINOIS · INDIANA · KANSAS · KENTUCKY
LOUISIANA · MARYLAND · MICHIGAN · MISSISSIPPI · MONTANA · NEBRASKA · NEVADA · NEW MEXICO · NEW YORK · NORTH DAKOTA · OHIO
OKLAHOMA · PENNSYLVANIA · SOUTH DAKOTA · TEXAS · UTAH · VIRGINIA · WEST VIRGINIA · WYOMING
ASSOCIATES: GEORGIA · IDAHO · NORTH CAROLINA · OREGON · SOUTH CAROLINA · WASHINGTON

Mr. **Fuqua**. Thank you, Mr. Lawrence.

Dr. Lee.

Dr. **Lee**. Thank you, Mr. Chairman and members of the subcommittee.

As president of the Institute of Gas Technology, which is an energy R&D organization that conducts R&D, I bring you a viewpoint from a person that actually performs R&D. As one who has spent his entire career in energy research, I am deeply concerned that today energy is no longer viewed as a national issue. The popular perception today is that energy supplies are bountiful, as if we in America have found some vast new energy resource.

The fact is, of course, that we haven't. In fact, our domestic energy availability is now not only no better than it was 10 years ago, it's worse. All that has happened recently is that world oil prices have dropped significantly. This fact is not surprising in that we all know that Middle Eastern oil producers can flood the market with cheap oil anytime they wish.

Oil prices can go down to $10 a barrel, and they will still make plenty of money. They are pushing the prices down to the point where we once again will be addicted to cheap oil and abandon totally energy alternatives.

In this regard, I must say I am personally encouraged and feel reinforced to hear the articulation by the members of this subcommittee on similar concerns.

The big drop in oil prices has already had its desired effect on us. Domestic oil and gas exploration has dropped significantly. Expenditures have been slashed. And in fact, as I listened to Mr. Webb, the rig count has dropped, as of yesterday, to 1,288 from 1,308. And it's going down still.

All this activity, or lack thereof, jeopardizes our ability to supply energy domestically in the future. As oil prices drop, the consumption will increase, and imports will increase.

Despite the $250 billion spent on domestic exploration between 1980 and 1984, proved oil reserves declined from 30 to 28 billion barrels. We therefore have not solved the energy problem at all. The United States today has the lowest proved reserve to production ratio in oil, only 9 years, of any major oil producing country in the world. We are merely returning to the old days of being dependent on imported oil.

Oil, as was said by Congressman McCurdy, is the largest import item in this country, being three times bigger than the automobile imports, which everybody complains about. That balance of payment deficit will balloon due to the combination of greater amounts of oil imports and reduced domestic production.

We look at the Nation as being on a collision course between growing dependence on imports and a contraction in investments for alternative energy sources. This may not be the time for massive expenditures for development in energy, but it is certainly not the time to salvage the Federal energy research effort. There is a clear need for a sustained Federal role to maintain and build a technology base in energy. That base, regrettably, continues to be eroded at a rapid pace. Congress should stay the course and continue to provide for a cost-effective, Federal presence in building an energy technology base. It is essential for the Federal sector to maintain a stability in funding that insures a flow of technology from the laboratory to commercial use.

The energy private sector, battered by the uncertainties and fluctuations of a world market controled by different national governments, simply cannot and should not take on this long-term responsibility.

A level of funding close to the authorization level of fiscal year 1985 and fiscal year 1986 seems appropriate to ensure that only the best research ideas are pursued and maintained. We do not seek expansions. Rather, we seek a sustaining of Federal energy research efforts consistent with due regard for the Federal budget deficit.

We at IGT each year make a thorough evaluation of the Nation's future energy requirements and the funding sources available from both Government and industry before we make recommendations to the Congress.

Guided by these considerations, we find programs in expanding the use of coal free of acid rain consequences, acquiring data for a greater production from and understanding of our large tight sand formations and geopressure reservoirs, developing high efficiency fuel cell technology for cogeneration, and advancing conversion technologies for renewable biofuels to meet the criteria of national interest and fiscal concern.

We are convinced that the guidelines for an effective national energy policy must maximize the availability of the broadest array of domestic energy sources. Hence, our recommendations to continue support of a variety of energy sources.

We are also convinced that we must maximize the efficiency of energy utilization and the preservation of environmental integrity. Hence, our recommendations for coal utilization technologies that are free of acid rain consequences and for highly efficient cogeneration technologies such as contaminant resistant molten carbonate fuel cells.

Therefore, as part of the gas industry's position on energy RD&D for fiscal year 1987, IGT recommends the following specific programs in which we are involved.

Under advanced research and technology development, IGT recommends $2 million for the treatment and utilization of fine coal as a new fuel form, including biocleaning, IRM bed gasification, and burn profiles and combustion.

Under surface coal gasification, IGT recommends $3 million to test pollutant recycle and particulate removal at 500 psi pressure in an existing PDU. We also recommend $2 million for the continuation of the ash chemistry and fluidization behavior research programs, which will provide fundamental data necessary for a better understanding of fluidized bed coal gasification processes.

Under unconventional natural gas, IGT recommends $1 million to continue the dye penetrant/CORAL analyses to better understand gas flow in tight formations.

In the geopressured/geothermal energy area, we recommend $4.2 million to fulfill DOE's contractual obligations in fiscal year 1987, to continue the operation of the Pleasant Bayou, Hulin, and Gladys McCall field wells, which would help resolve technical issues on the production of hydrocarbons and brine and the generation of electricity from the fluids produced.

Under fuel cells, IGT recommends $2 million to continue the development of contaminant resistant molten carbonated fuel cells capable of processing gases containing sulfur and chlorine.

Under biofuels, we recommend $1.35 million for the joint DOE funding of an ongoing GRI program at the Walt Disney World to biologically convert municipal solid waste, industrial waste, and sewage sludge to methane gas.

We also recommend $2 million for the thermochemical conversion of municipal solid waste or refuse-derived fuel in an existing high-pressure inert-solid fluidized-bed PRU.

I thank you for giving me the opportunity to present my views. I will be happy to answer questions.

[The prepared statement of Bernard Lee follows:]

Statement of Bernard S. Lee, President
Institute of Gas Technology
Before the House Committee on Science and Technology
Subcommittee on Energy Development and Applications
Hearings on FY'87 Authorization for the Department of
Energy's Fossil Energy Research and Development Program

March 4, 1986

Mr. Chairman and Members of the Subcommittee:

My name is Bernard S. Lee. I am President of IGT, a not-for-profit energy R&D organization in Chicago.

Having spent my entire career in energy research, I am concerned that energy is no longer viewed as an important issue today. There are those who say that funding of energy research should be cut drastically or even eliminated. They see the trends of the recent past - falling prices, supply surpluses - as irrefutable proof that forecasters who predicted the world was running out of fossil fuel resources were wrong. Yet the current energy surplus situation is no more proof that the "experts" were wrong than the supply interruptions of the '70's were proof that their predictions had suddenly come true.

Despite the recent decline in oil prices, our long- or even medium-term domestic energy availability is not one whit better than it was ten years ago; in fact, it is worse. Even before the current "free-fall" in oil prices, drilling for oil and gas in the U.S. had begun to decline rapidly. Well completions were off 20% in 1985 from the previous year and down nearly 30% from the 1981 record. The current drop parallels last year's decline in the rig count and 1986 has gotten off to a bad start with 31% fewer operating rigs than a year ago. Domestic spending on exploration and development has plummeted from almost $40 billion in 1982 to $27 billion in 1984 and dropped another 15% in 1985. If oil prices stay down for 2-3 years, investment in exploration and development will decline even more. When you consider that drilling is increasingly moving to remote and difficult locations that are expensive to develop, the magnitude of the decline becomes even more serious. All the Persian Gulf producers are doing is pushing the oil price down to the point where we will again be addicted to "cheap" oil, while totally neglecting alternative energy developments.

It's worth noting that despite the $250 billion spent by the petroleum industry on domestic exploration over the 1980-84 period, proved oil reserves declined from 30 to 28 billion barrels and the U.S. has the lowest ratio of proved oil reserves-to-production (only 9 years) of any major oil producing country. Our nation's proved gas reserves in the lower 48 states have similarly declined and are now equivalent to only 10 years production.

Several months ago, even when the universal prognosis was that oil prices would remain stable, several industry and government forecasts were published that foresaw a significant decline in domestic oil production from nearly 9 million bbl/day in 1984 to 7-8 million bbl/day by the end of the century, and a concomitant rise in imports from 30% to half of our total oil demand over the same period. Oil imports are already our single largest import item - three times greater than the second largest, automobiles - and could cost as much as $100 billion annually by 2000.

However, even these forecasts are outdated by recent events, since lower prices will boost consumption and further discourage exploration and production investments. Lower prices will also discourage private sector research and development outlays because they constrain energy companies' cash availability, and postpone the prospects of commercialization of alternative energy sources and innovative production techniques. Further, oil company research budgets have been hit in some instances by the double whammy of drastically lower crude prices, coupled with significant debt loads and redeployment of fiscal resources. They are not just cutting exploration, but in even greater measure, R&D efforts. Excellent laboratory facilities and professional research capabilities are being decimated.

The argument has been made that increased dependence on oil imports would not adversely affect our energy security, since we and our allies have switched our sources away from the Persian Gulf to non-OPEC producing areas and more "secure suppliers". But, a recent GAO report cautions against the U.S. taking for granted the ability and willingness of individual Caribbean countries to sustain or increase oil supplies to us. Mexico and Venezuela were our number one and number three crude oil suppliers. The GAO report stressed the limits both of these countries have placed on exports to the U.S., and that they have either curtailed or delayed maintenance of existing oil facilities as well as development of new fields. An increase in U.S. demand could force a resumption of Middle Eastern petroleum imports.

It's also important to keep in mind that the major non-OPEC discoveries - the North Sea, the North Slope - were the result of exploration expenditures made before 1973-74 and that similar investments are not being made today. Thus, unless major new discoveries are made outside the Persian Gulf - and this seems unlikely - we may be back on bended knee to the Persian Gulf producers. Dependence will increase not only in the U.S. and other industrialized countries but in the developing countries as well. This indeed is part of OPEC's strategy - to boost oil demand worldwide and to discourage new discovery efforts, heightening worldwide dependence on OPEC.

This nation is on a collision course between growing dependence on expensive imports and a contraction of investments in the development of viable alternatives. Although this may not be the time for massive expenditures on development, this is certainly not the time to savage the federal energy research effort. Rather, the Congress should "stay the course" in continuing to provide for a cost-effective federal presence in the support of energy research. Now is the time to channel funding into next-generation technologies so that we have them "on the shelf" to be deployed when they are needed. But, you can't put a technology "on the shelf" for later use if there is an incomplete data base. One result of omitting critical links in technology development, is that the government will be unable to receive an adequate return on its investment in energy R&D of previous years.

We have suggested in past testimony that we need a mature national energy policy that directs a balanced and sustained program to develop appropriate technologies to meet our future energy needs. This policy should ensure a smooth flow of technology from the laboratory to commercial use. There is a need for a sustained federal role in energy research. The private sector is unlikely to continue the development of a broad array of energy technologies once federal support is interrupted, because the private sector can only concentrate on the short term in view of the arbitrary and politicized nature of the world energy arena. The private sector cannot risk its resources to strive for long-term stability when faced with the uncertainties and fluctuations of a world market controlled by different national governments.

A level of funding close to the Appropriation levels of FY'85 and FY'86 would appear to be appropriate to ensure that only the best research ideas are pursued. We do not seek expansions, rather we seek a sustaining of federal energy research efforts consistent with due concern for the federal budget deficit. Bear in mind the impact of adequate energy supplies on the Nation's economy: employment, GNP, the homeowner. We have already witnessed the impact of crude prices on the world economy. For example, with every $5 drop in the price of oil, our cost of living drops by 1%. The reverse is also true. Therefore, Congress and the Executive Branch should establish a sound energy policy and set priorities in the federal budget accordingly.

IGT has followed rigorous procedures in formulating recommendations to Congress for assistance on the budget. Each year we apply a thorough technical evaluation of the Nation's future energy requirements and the funding sources available from both government and industry. With this in mind, we are proposing a suite of research efforts which are small scale, inexpensive approaches to a variety of energy problems. As part of the gas industry position on energy RD&D for FY'87, we recommend the following specific programs in which IGT is involved:

Advanced Research and Technology Development

IGT recommends $2.0 million to study biocleaning, the IRM bed, and burn profiles to increase the utilization of fine coal as a new fuel form.

Surface Coal Gasification

IGT recommends $3.0 million to test pollutant recycle and particulate removal at 500 psi pressure in an existing PDU. IGT also recommends $2.0 million for the continuation of the ash chemistry and fluidization behavior research programs which provide fundamental data necessary for better understanding of fluidized bed coal gasification processes.

Unconventional Natural Gas

IGT recommends $1.0 million to continue dye penetrant/CORAL analyses to better understand gas flow in Devonian shales, tight gas sands, and coal seams.

Geopressured Resources

IGT recommends $4.2 million be provided for DOE to fulfill its contractual obligation in FY'87 for the continued operation of the Pleasant Bayou, Hulin, and Gladys McCall field wells to resolve technical issues on production of hydrocarbons and brine, and generation of electricity from the fluids produced.

Fuel Cells

IGT recommends $2.0 million to continue the development of a contaminant resistant molten carbonate fuel cell capable of processing gases containing sulfur and chlorine.

Biofuels

IGT recommends $1.35 million for the joint funding of an ongoing GRI program at the Walt Disney World to biologically convert municipal solids waste (MSW), industrial wastes and sewage sludge to methane gas. IGT also recommends $2.0 million for the thermal conversion of MSW or refuse-derived fuel (RDF) in the existing high-pressured, inert-solid fluidized-bed PRU.

Thermal Energy Storage

IGT recommends $2.0 million to continue research in industrial applications of the composite-phase-change TES technology by conducting tests of the composite media in a PDU, and then using the data obtained to design a cost-shared, proof-of-concept facility to be located at an industrial site.

Thank you for the opportunity to present my views. I will be happy to answer any questions.

Selected Energy Research

Recommendations FY'87

PROGRAM FACT SHEET

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

FINE COAL UTILIZATION

Finely ground de-ashed coal (fine coal) is a new fuel form which has great potential to improve the utilization of coal in an environmentally responsible manner. It is therefore important to perform research on the cleaning, gasification, and combustion of fine coal.

Biocleaning:

Several processes have been developed which utilize a wet grinding process to manufacture fine coal. The resulting product, fine coal in wet slurry form, is ideally suited for microbial processing. A method for microbial removal of sulfur and nitrogen pollutants from fine coal offers significant advantages when compared to the conventional chemical methods for on-stream gas phase removal of H_2S and NH_3 from fuel gas, or SOx and NOx from flue gas. Gas phase processes that operate at elevated temperature (and possibly pressure) are susceptible to process upsets, and must be continuously operated on a real time process basis to be fully effective.

On the other hand, microbial removal (Biocleaning) of pollutants can be accomplished at low temperature and pressure and can be operated totally independent from the gasification or combustion process. In the event that a relatively minor upset occurs in the Biocleaning process, clean fuel feedstocks can be obtained from inventory with no subsequent release of pollutants. The cost of chemicals which are required for gas phase cleaning will also be eliminated.

IGT is currently researching the microbial removal of sulfur from fine coal. Most of the pyritic sulfur is physically removed during fine coal production. Removal of the organic sulfur as well may result in a product fuel which can be gasified or combusted and meet New Source Performance Standards (NSPS) without further processing. IGT recommends that this program be continued and expanded to include microbial denitrification as well.

Fine Coal Gasification:

Gasification of fine coal, which measures less than 40 microns, presents technical challenges totally different from those addressed in the gasification of raw coal. IGT recommends the investigation of a gasification process which can utilize fine coal directly: internal recirculating material, fluidized-bed (IRM bed).

Fluidized-bed processes, which are favored for coal gasification because of their high throughput and thermal efficiency can not process coal particles smaller than 40 microns. A feedstock such as fine coal, which is composed entirely of very fine particles, will not remain in the fluidized-bed for sufficient residence time required for complete gasification. IGT has developed the IRM bed which is designed to process ultra fine particles. An inert material (sand) is recirculated within the bed. This serves to hold the fine coal in the bed for sufficient residence time, while promoting mixing and efficient heat transfer. IGT recommends that a research program be conducted in an existing, process research-scale IRM bed to determine the effect of various operating parameters on the gasification of fine coal.

Fine Coal Combustion:

Burn profiles of various fine coals which have been microbially treated for desulfurization and/or denitrification should be generated to provide a comparison of coal combustion characteristics. IGT recommends a laboratory-scale research program to provide basic data required to evaluate the use of fine, microbially-treated coal for combustion.

IGT recommends $2.0 million to investigate biocleaning, the IRM bed, and burn profiles to increase the utilization of fine coal as a new fuel form.

SURFACE COAL GASIFICATION

POLLUTION ABATEMENT:

More efficient, cost effective gas processing plants for surface coal gasification are needed. Typically, over 30% of the cost of an integrated coal gasification facility is attributable to the gas purification facilities.

These facilities are composed primarily of particulate removal, waste heat recovery, gas upgrading, and pollution abatement systems. Ideally, the development of a new gas processing configuration will include efficient particulate removal and internal recycling and destruction of pollutants which remain after primary treatment. The recovery of these remaining pollutants is currently accomplished in secondary removal systems which are extremely expensive to operate because of the dilute content of the pollutants in the gas stream.

IGT has developed a concept for an Advanced Gas Treatment (AGT) system, which addresses both particulate removal and pollutant recycle. The development of this system will result in a highly efficient, dramatically simplified gas processing plant, which could be applied to any gasifier system for any application (chemicals production or power generation).

Particulate Removal:

Gas turbines or other downstream process equipment require a very low particulate level in the gas stream to prevent shortened equipment life. Conventionally, cyclones are used to remove most of the particulate matter from the gas stream. However, cyclones alone do not provide sufficient particulate removal. IGT has tested a novel ceramic filter and has found that operation of the ceramic filter in conjunction with cyclones results in virtually complete removal of particulates. Ceramic filters must be operated cyclically to allow for filter cleaning, therefore, cycle time is an important factor in the life and cost of a ceramic filter system. Tests performed at IGT have also shown that the placement of baffles in a fluidized-bed can reduce the amount of particulates. It appears that the integration of in-bed baffles, cyclones, and ceramic filters will result in very high particulate removal efficiency and longer equipment life. IGT recommends a research program which will include modification of an existing process research unit and the collection of data on the efficiency of a particulate removal system consisting of in-bed baffles, cyclones and ceramic filters.

Pollutant Recycle:

Pollution abatement facilities for coal gasification plants include separate systems for removal of ammonia and hydrogen sulfide from the product gas, as well as systems to recover anhydrous ammonia and to convert hydrogen sulfide to a saleable by-product (usually elemental sulfur). In the case of hydrogen sulfide conversion to sulfur, a tail gas is formed which contains hydrogen sulfide and sulfur dioxide in sufficient quantity to require secondary treatment.

Conventional pollution abatement processes are expensive to operate and are often susceptible to upsets which result in unacceptable levels of sulfur and nitrogen compounds in the product gas. It is extremely desirable to develop a simpler pollution abatement system which can be used for all coal gasifiers regardless of configuration or operating pressure.

IGT has developed a concept for total recycle and destruction of all pollutants which would entirely eliminate the conventional ammonia removal, ammonia recovery, and secondary system for the removal of hydrogen sulfide and sulfur dioxide from tail gas formed during sulfur recovery.

This system consists of a water scrubber located directly after the particulate removal system and waste heat boiler.

The water scrub will remove ammonia from the product gas, and because the gas temperature is lowered, polycyclic and polynuclear aromatic compounds and light oils will also condense and be removed. The water from the scrubber will then be steam stripped to remove the pollutants, which are once again in a gaseous form much more concentrated than they were in the original coal gas stream.

This concentrated stream, together with the hydrogen sulfide- and sulfur dioxide-containing sulfur plant tail gas stream will be recycled to the gasifier at a point where reducing conditions prevail. Sulfur dioxide will be converted back to hydrogen sulfide, to be removed in the conventional sulfur removal system downstream. Ammonia, light oils, and heavier hydrocarbons will crack to lighter gases, including methane. At equilibrium, a clean gas stream which is acceptable for either power generation or chemicals production is produced.

Pollutant recycle systems previously considered have involved the recycle of sulfur pollutants only, and only at low pressure. The proposed system handles all pollutant streams; ammonia, sulfur, tars, and light oils. This greatly reduces overall plant complexity and reduces capital and operating costs.

IGT recommends $3.0 million to test pollutant recycle and particulate removal at 500 psi pressure in an existing PDU.

RESEARCH ON ASH CHEMISTRY AND FLUIDIZATION BEHAVIOR

It is important to continue basic research activities to provide the data on coal ash chemistry and fluidization behavior which is necessary input for accurate gasification models. Because gasification models are a cost effective means of simulating the effects of varying process parameters and feedstocks on gasifier performance and product quality, it is desirable to refine these models as much as possible.

IGT is currently performing research in both ash chemistry and fluidization behavior. The results of these programs provide data to all fluidized-bed gasification processes.

Ash Chemistry:

IGT is currently performing research utilizing a hot stage microscope with a video camera and a penetration viscometer designed and built by IGT expressly for this program to examine the mechanisms of ash formation for a wide variety of coal chars and to determine ash properties.

The coupling of the video camera and the hot stage microscope permits direct, visual observation of ash fusion, while the penetration viscometer provides data which aid the understanding of ash agglomeration behavior.

Fluidization Behavior:

IGT is currently operating an advanced multi-purpose research reactor to determine the behavior of both coal and ash particles in a fluidized-bed. Basic data on the interaction of the particles with fluidizing gas jets, other particles in the bed, and mechanical devices such as cyclones is being determined in this program.

IGT recommends $2.0 million in FY'87 for the continuation of the ash chemistry and fluidization behavior research programs which provide fundamental data necessary for better understanding of fluidized-bed, coal gasification processes.

UNCONVENTIONAL GAS

Geopressured/Geothermal Energy:

Geopressured/geothermal energy involves the coproduction of natural gas and hot brine. It is well known that there are thousands of TCF of methane in the ground in conjunction with geopressured reservoirs. In order to produce cost competitive natural gas, and thus attract commercial risk capital, there are technical issues that need to be resolved. The Department of Energy currently has underway as part of its geopressured resources program, a research project involving specially drilled geopressured/geothermal wells in the Texas/Louisiana Gulf Coast area. This project includes production testing coupled with scientifically sound data collection and analysis necessary to determine:

- the quantity of hydrocarbons produced with the brine
- the thermal and hydraulic energy content of the produced brine
- the best methods to produce electricity from both the hydrocarbons and the energy content of the brine
- optimum techniques to treat the brine to inhibit corrosion and scale formation, remove solids, and dispose of the produced brine in a environmentally sound manner.

This project will provide information which will be available to industry and, therefore, lower the perceived risks associated with development of this important resource.

IGT recommends $4.2 million be provided to continue funding the existing DOE contract in which three field wells, Pleasant Bayou, Hulin, and Gladys McCall, will be used to resolve technical issues on production of hydrocarbons and brine, and generation of electricity using the energy content of the produced fluids, thus reducing the risk currently inhibiting industrial development of this valuable resource.

Improved Reservoir Analysis for Tight Formations:

Tight sands, Devonian shales and coal seams are unconventional sources of natural gas which have lower permeability than conventional reservoirs. Current work has revealed that the mechanisms which control gas production in these media are very different from those found in conventional reservoirs. Additional work is required in order to understand these basic mechanisms and properly reflect them in hydraulic fracture evaluation. Such work would provide invaluable support and guidance to ongoing field test research efforts by increasing the ability to forecast reserves, and design stimulation treatments and production strategies to exploit these resources. IGT has developed specialized instruments and techniques for studying these tight reservoirs.

The dye penetration microscope technique allows the studying and photographing of the gas flow paths in the tight rocks under the actual conditions existing in the reservoir. A core sample is confined, in specially designed laboratory equipment, under stresses representative of reservoir conditions. The sample is then injected with a special fluorescent dye which, when energized, allows viewing and photographing of the flow paths in the rock. The flow paths in the tight samples are invisible under normal techniques using transmitted light.

The results from the dye penetration microscope techniques are then compared with the rock properties measurements from IGT's specially designed Computer Operated Rock Analysis Laboratory (CORAL). CORAL has been used to determine reservoir properties (porosity, pore volume compressibility, and gas permeability) of these tight reservoirs. It has shown, for example, that better understanding of the gas/liquid relative permeability behavior of these reservoir materials is required to accurately predict gas production potential.

IGT recommends that $1.0 million be provided to continue dye penetrant/CORAL analyses to better understand the mechanisms that control gas flow in tight reservoirs.

BIOFUELS

The conversion of municipal solids waste (MSW) and/or industrial wastes to gas produces a clean, useable form of energy, while simultaneously eliminating disposal problems and associated costs. Both biological and thermal conversion processes for waste gasification should be researched.

Biological Conversion:

IGT designed and is operating a biological conversion test facility which is located at Walt Disney World in Orlando, Florida. This facility currently converts a mixture of water hyacinths and sewage sludge to methane gas. This test facility should be used in a program to broaden the application of the process to a mixture composed of municipal and/or industrial wastes and sewage sludge with a low concentration of water hyacinths. The goal of the program will be to develop a process that disposes of municipal/industrial wastes and sewage sludge at a 20:1 ratio, the typical production ratio of most municipalities.

IGT recommends $1.35 million for the joint funding of an ongoing GRI research program at the Walt Disney World test facility to convert MSW, industrial wastes and sewage sludge to methane gas.

Thermal Conversion:

Technology for recovery of energy in the form of steam from burning of municipal solid waste (MSW) or refuse-derived fuel (RDF) is commercialized, but has limited application because the steam must be utilized on-site. The thermal conversion of RDF or MSW to a fuel gas is an attractive alternative.

Pressurized fluidized-bed gasification of RDF or MSW would provide high throughput, high conversion of organic carbon, and a fuel gas which can be used directly for combined cycle power generation or sold for off-site use. IGT recommends a research program to investigate pressurized, fludized-bed gasification of RDF and MSW utilizing an existing process research unit (PRU).

Because RDF is more highly processed than MSW, the program should begin by conducting parametric gasification tests with RDF to determine the effects of temperature and pressure on product gas quality, as well as an analysis of all process streams for potential pollutants. The data obtained for RDF will be helpful in directing the research for MSW, which contains inorganic materials in addition to the components found in RDF.

Feeder designs for MSW should be evaluated and gasification tests in an existing sloping grid bottom for the separation of the inorganic solids present in MSW should be conducted in an existing gasifier. The effects of seasonal variations in the composition of MSW should also be researched.

IGT recommends $2.0 million for thermal conversion of MSW or RDF in the existing high pressure inert fluidized-bed PRU.

FUEL CELLS

Contaminant Resistant Molten Carbonate Fuel Cell:

Molten carbonate fuel cells show significant performance degradation when exposed to contaminants, such as sulfur and chlorine, in the feed gas. Since it is complex and expensive to remove all such contaminants from a coal-derived feed gas, a contaminant resistant molten carbonate fuel cell would maintain a high level of performance while simultaneously decreasing the complexity and cost of the feed gas cleanup process. The optimum coal gasifier/molten carbonate fuel cell combination will minimize cleanup of the coal gas, maximize contaminant resistance of the fuel cell, and withstand occasional unexpected gasifier upsets without permanent damage to the cell. In developing such a contaminant resistant fuel cell system, IGT has determined and correlated the effects of some of these contaminants, such as hydrogen sulfide and sulfur dioxide, on cell behavior and has accumulated sufficient data to begin design and testing of different proof-of-concept configurations. Initial evaluation of one of these designs, the membrane barrier anode, indicates that it could also solve other molten carbonate fuel cell problems such as anode creep, carbonate management, and permit the use of internal reforming catalysts without degradation by the electrolyte.

IGT recommends $2.0 million to: 1) continue the development of the contaminant resistant molten carbonate fuel cell by determining the effect of chlorides on fuel cell performance and identifying and testing materials of construction resistant to contaminant-induced corrosion; 2) identify and test sulfur tolerant internal reforming catalysts; 3) initiate development of contaminant resistant molten carbonate stacks; and 4) determine the most efficient/cost effective coal gasifier/contaminant resistant molten carbonate fuel cell combination.

Thermal Energy Storage

There are numerous applications in which either the availability of high temperature thermal energy does not match the short term needs or in which the energy demand cannot be economically met by the short term supply. An efficient high-temperature direct-contact thermal energy storage and recovery system (TES) would satisfy these short term energy mismatches. Examples include:

(1) residential heating where energy stored at off-peak rates could be used for heating during peak periods, thus leveling utility loads, reducing energy costs, and minimizing the need for new power plants/distribution capacity.

(2) industrial periodic processes such as those in the brick, ceramic, glass and steel industry in which energy normally exhausted up the stack during parts of the cycle can be recovered and stored for use to meet later process requirements, thereby replacing primary fuels.

(3) solar electric power generation, either terrestrial or for space applications such as the space station and the Strategic Defense Initiative in which energy can be stored when available for use when it is dark.

(4) thermal management systems will be sued as part of any SDI space-based weapons system to control the temperatures of equipment such as refrigerators, compressors and energy weapons. High temperature TES could be used in such a thermal management system to absorb the waste heat created by such devices thus keeping them ready for reuse without fear of overheating. The energy stored in the TES would then be disposed of over a relatively long period of time without the need for excessively large radiators.

Currently high temperature industrial TES is accomplished by heating a ceramic brick during "charging" and cooling the brick to recover the heat during "discharging". The low energy storage capacity of the brick results in large, heavy, heat storage systems. Increased energy storage capacity can be achieved using phase change materials (PCM) which would be alternately melted and solidified, thus storing and releasing the energy at the desired temperature. Previous atempts at using PCM's have proven impractical because of the change in volume upon melting and solidifying, and the great resistance to heat flow through the solid material.

IGT has developed a composite TES media in which a PCM of the desired melting temperature is contained within a proous ceramic. The composite retains the PCM both in the solid and liquid phases, thus storing large amounts of heat while avoiding the problems of external volume change and poor heat transfer. When compared to ceramic bricks, the composite TES system results in 45% less weight and 35% less volume at an increase of more than 25% in efficiency. This composite TES technology can be tailored to any of the specific applications mentioned earlier. Information obtained on one application may benefit other applications.

This technology is the subject of an International Energy Agency (IEA) annex in which the U.S. government has responsibility for the development of a composite latent heat TES media and subsequent design, installation, instrumentation and operation of a full scale demonstration in the brick/ceramic industry.

IGT recommends $2.0 million to continue research on applying the composite phase change TES technology to industrial applications, specifically by increasing the heat storage capacity of the composite, constructing a PDU, conducting tests of the composite media, and using the PDU test data to initiate design of a cost-shared, proof-of-concept facility to be located at an industrial site.

Mr. **Boucher** [acting chairman]. Thank you, Dr. Lee.

I would like to extend the subcommittee's appreciation to all the members of the panel for their very thoughtful testimony today.

Mr. Webb, the details are not clear at this time. It is not apparent that we will have a program in this area. But as you probably know, the Department of Energy has recommended a joint R&D venture, the vague outlines of which would be that two or more private firms would provide more than 50 percent of the funding; and then the balance would be provided by DOE for research and development.

Does that have any appeal to you or to your institute? Do you think you could participate in such a program?

Mr. **Webb**. Mr. Congressman, yes. We generally support that R&D venture application.

Our only concern really is that DOE not use that to supplement generic technology-based R&D. It ought to be restricted to field-test type activities where you can bring in, if you would, an industrial partner, GRI maybe as a cofunder to go forward with some programs. We would be interested in talking to DOE about underground coal gasification and some of their unconventional gas work as well as fuel cells, but again it does not take the place of the generic R&D which has got to be done in the laboratories of the industry and the universities. And you know, there's no way you can get cofunding for those activities.

Mr. **Boucher**. Mr. Lawrence and Dr. Lee, would you care to respond on behalf of your organizations?

Mr. **Lawrence**. I would certainly concur with the criteria that Mr. Webb has laid out. I think we certainly encourage the private sector cofunding. That's what is eventually going to bring research into commerciality. That's the desired end result.

But we do have this need for the long-term, high-risk, high-potential generic research. And nothing fits this better than our recommendation for beefing up the geosciences. This huge potential that I have described can best be defined and pursued by strong emphasis on research in the geoscience area.

Mr. **Boucher**. Dr. Lee.

Dr. **Lee**. Yes, I think that there is a clear role for the Federal sector to support research from the generic research all the way through commercialization. When it gets to the commercial stage, I think there is a place for joint venture. But we would not like to see that take the place of or as an excuse to cut back on the basic building of a technology base.

Mr. **Boucher**. I would like to ask Mr. Webb what kinds of programs could potentially be funded, kinds of gas projects, through the clean coal technology reserve, as based upon the program opportunity notice that was recently submitted by DOE? Do you anticipate proposals being made from gas organizations? What kinds of projects do you think will be submitting bids?

Mr. **Webb**. Mr. Congressman, since we are not a contractor of DOE, we won't be submitting proposal ourselves. We have been holding conversations with some of our member companies and also with some other firms. We would at least hope that there would be some proposals submitted where we would use gas in conjunction with coal to help meet some of our environmental requirements in what we think is the most cost-effective manner.

If those types of proposals are submitted to DOE, that we have notified DOE that we would be interested in perhaps cofunding. The one concern that I think that everybody should—and it has been expressed here this morning—but the one concern we have is that you're talking about repayment from profits. Now, many of these projects are essentially a way to reduce the cost of complying with federally mandated emission laws. They don't increase the profit, you know; all they do is help you meet, if you would, an environmental law in a more cost-effective manner. Therefore, I am not quite sure how that is going to work.

If they are talking about a firm that has a patentable process, if that process is demonstrated and there is revenue stream from the patents, then that in fact probably makes sense. If they are talking about a utility—let's say a utility that burns coal and they're now going to burn 25 percent gas with the coal and demonstrate that you can do that to reduce the NO_x and the sulfur dioxide, there's no increased profit there. All they're doing is reducing their capital cost to meet federally mandated laws.

So, I think that potentially could be a very real problem with the program as it is proposed.

Mr. **Boucher**. Do you think there will be a proposal submitted by gas firms?

Mr. **Webb**. I think probably what we will see is proposals submitted by architectural engineering firms but to use some maybe gas utility facilities as the test bed, or electric utility facility as the test bed. That would be what I would anticipate.

Mr. **Boucher**. Do you think that the potential for having those proposals submitted has been significantly reduced or retarded as a result of the Department of Energy's program opportunity notice, which effectively makes the program a loan as opposed to a grant?

Mr. **Webb**. I don't think we will know that until after their conference they are holding, I believe they said, on March 6. For instance, we are going to ask some of these same questions I just brought up here so that we can really get a better definition.

Mr. **Boucher**. Mr. Lawrence, can you give us some indication how natural gas prices have responded in the wake of reducing world oil prices? Do you find any regional variation in the response throughout the United States?

Mr. **Lawrence**. Mr. Chairman, the natural gas prices do respond somewhat and are, in the field, following the oil prices down but perhaps not to the extent that many might expect. We have already had severe pressure on natural gas prices in the field because of a current oversupply and very severe gas-to-gas competition. So, I think that is mitigating the impact that the decline in crude oil prices is having.

However, it is contributing to a further decline in the field price of natural gas.

Mr. **Boucher**. If oil prices remain in the $12 to $13 per barrel range for a couple of years, as many anticipate, will that further depress natural gas prices? I assume it would.

Mr. **Lawrence**. I guess reasonable minds can differ on that, Congressman. I think the conventional wisdom is that our markets would erode, that we would lose certain major industrial markets to the lower priced residual oil.

Initially that can happen and has happened in some instances. But again, I think it has been mitigated very significantly by the fact that gas prices are already down and already under a lot of pressure to compete with other sources of gas.

On the other hand, the lost market initially could very well be offset by a stimulation of the economy and particularly in some of the major gas consuming industries that have been hard hit by the international trade, such as steel, petrochemical, et cetera.

So, I think our biggest concern is not so much in the area of market loss as a result of the very low level of crude oil prices. Our bigger concern is the lower level oil price together with low natural gas prices in the field and the declining rig count. All of these things, if they are continued for a long period of time, could have a serious impact on our conventional domestic natural gas supply. That is our biggest concern.

Mr. BOUCHER. Thank you.

Dr. Lee, a couple of questions for you. I have a particular interest in helping to promote the market for coal. I wonder if you could comment on how the research recommendations that you have made would affect the coal market. Are there particular ones of those that have the potential for expanding the market either for high or for low sulfur coal?

Dr. LEE. Yes, one of the programs we recommend is a new fuel form, fine coal. Now, that coal, once mixed into water slurry, can be used in combustion application directly to replace oil. But before you can do that, you have got to get the sulfur and ash down. Current technologies have been able to remove most of the ash but only part of the sulfur. So, what we are recommending is a program that would biologically remove the sulfur without going to the high temperature and pressure of gasification and then produce a fuel which is, when burned, totally able to meet the new source performance standards.

We are also recommending studies of the combustion characteristics of such new fuel form of fine coal after desulfurization, after de-ashing. So, we think this is something that can appear in the near term for application and is one of the greater things that could stimulate the use of coal in this country. Many States that produce coal cannot use a high-sulfur coal because of these limitations. This would expand the use both domestically and would help the export also.

Mr. BOUCHER. I would like to ask you about the status of just a couple of projects.

In the past, this committee has expressed through report language its support for funding for various aspects of coal research and your field, high pressure ash agglomerating gasification, particle removal, and pollutant recycling in particular. Can you tell us what the status of that research is? As I understand it, we never have really been able to derive funding through the entire process for that. Perhaps you could comment on the status of those projects and their future prospects.

Dr. LEE. The ash agglomeration gasification project, which this committee supported, did not get through the ax in the DOE, so we never got started in DOE. We are very pleased that the Gas Research Institute has picked up a portion of the research at our organization. We are keeping that activity alive. We are trying to find greater application for the ash agglomeration gasification technology.

We see it as part of the ongoing GRI program. It is included in Mr. Webb's testimony for his recommendation of fiscal year 1987 funding.

On the pollutant recycle and particulate removal project, which we reported on last year, again we appreciate this committee's support, but it didn't quite make it. We think this is another wonderful way for longer term use to eliminate the pollutants from being generated and collected and instead remove the sulfur as elemental sulfur and take all the rest of the pollutants back to the gasification unit for conversion so that on a closed cycle basis, the only thing that will be removed will be as a pile of sulfur on the ground; and there's no other emissions of pollutants.

We recommend it again this year. We would like to have this committee's support once more and will go to bat again.

Mr. BOUCHER. Thank you, Dr. Lee.

Mr. Packard.

Mr. PACKARD. Mr. Webb, why do you feel that the phosphoric acid fuel cells need to be continued with Federal funding?

Mr. WEBB. Primarily, Congressman, because within about 2 or 3 years commercialization of what have been about 10 or 12 year programs, cofunded with industry mostly on a 50–50 basis. The industry in 1981 and 1982, when this administration came into office, said that industry would fund near-term research. We shifted our program, the Gas Research Institute, into the near-term aspects, worked through a cofunding program with DOE to fund the long-term research. We are now funding the field test activities which should be completed in about 1 year from now.

We need DOE to put up their 50 percent of the money for the long-term research so that in the 1988–89 timeframe the technology base is there for the manufacturer to make a commercial offering to our member companies. If you terminate the program now such that the commercial offering is never made, I don't see how the taxpayers ever get a benefit for investing in R&D that you always quit when you get close to a product or to an end objective. And that's essentially what they're proposing again.

So, it means that if the DOE funds go away for phosphoric acid fuel cell research, which is the one that's nearest to commercialization, so they can concentrate on some more long-term technology, when the next long-term technology gets closer, then you'll shift to some other long-term technology. It's an unending cycle of never ever bringing anything to the marketplace. And we just don't think that is sound national policy.

Mr. PACKARD. Thank you.

Mr. Lawrence, in light of the acid rain problems, do you think that can best be resolved through the use of natural gas as perhaps a more economically viable process rather than scrubbers and other expensive equipment? Or do you think clean coal research has potential of solving the acid rain problem better than natural gas? Where do you feel we ought to concentrate our efforts?

Mr. **Lawrence**. Congressman, we try not to be too dogmatic on that problem, but I do see in the Drew Lewis report, for example, an almost total focus on a clean coal technology and no mention whatsoever the contribution that natural gas could make. The only contribution in that overall discussion came from the Canadian side. Canadians have an oversupply of natural gas as well as we do.

So, we have a situation on both sides of the border where we can benefit our producers of natural gas and a depressed economy in the producing segment of the natural gas industry by selling more natural gas, and at the same time, we submit, make a significant contribution to reducing sulfur oxides. We don't offer it as a panacea. We offer it as a very significant contribution that can be done immediately. Its impact can be evaluated, we think. And we would certainly let these stand the test of close scrutiny.

We think in many instances, perhaps most instances, that a combined blending of natural gas with coal would be much more economic than scrubbers.

Mr. **Packard**. The current and projected energy consumption rates, understanding those, how would you suggest that DOE balance this, their energy research and development budget?

Mr. **Lawrence**. Well, again, we have recommended about a 22-percent lesser overall gas-related research than we submitted to this committee last year. And that would be $156 million. It is more than this committee approved. I think in fiscal year 1986 it approved something like $128 million, which was about twice what DOE proposed. For that we are certainly grateful. We think this committee was acting very responsibly.

But we think it's time to begin to reassess, reassign, reshift those priorities. And gas-related research has a significant contribution. Again, we are not tossing it out as a panacea, do away with other areas of research; but it's certainly entitled to a very significant play in this game.

So, the short answer to your question is $156 million.

Mr. **Packard**. Dr. Lee, how does your recommendation concerning research on surface coal gasification differ from DOE?

Dr. **Lee**. Well, the current DOE program, if you include the funding from the deferrals of 1986 funds, it leaves very little. If I remember the numbers right, it's something like $5 million for surface gasification, which really is a kind of a decimating way of conducting research for our largest energy resource in this country, namely coal.

The elements that we propose, which is part of the overall package of gas-related coal utilization technology, which Mr. Webb proposed in his testimony, I think, gives a reasonable basis for maintaining coal research technology, especially in light of the fact that that is our greatest resource. We have to utilize it in a clean way.

So, I think the DOE program for 1987 is totally inadequate. It needs to be supplemented by congressional action.

Mr. **Packard**. Do you see coal as being perhaps the future energy source for the United States?

Dr. **Lee**. Yes; I think in the long run it has to be, but coal is just a solid form of hydrocarbon, just like gas and oil. We have been using them in a balanced fashion, oil and gas and coal together. I think we will continue to use them in a balanced way in the future. But in terms of total energy content, coal outweighs the other two by far. So, we need to pay much more attention to the development of the clean technologies than we have heretofore.

The clean coal initiative is fine, but that addresses those technologies which are already ready for commercialization today. And that does not address the development of new technologies for the future.

Mr. **Packard**. Thank you, Mr. Chairman.

Mr. **Boucher**. Mr. Barton.

Mr. **Barton**. Thank you, Mr. Chairman. I have just a few questions.

Have any of your organizations been approached by DOE on this cooperative R&D program that they're talking about? Have you actually had any discussions at all on what you would do with them?

Mr. **Webb**. We have had some informal discussions with the Department of Energy. We have also actually sent correspondence to them indicating our desire to sit down and discuss it with them when they get the guidelines better formulated. We have not had a response yet. But I think it's probably a little early since they are proposing this for an 1987 initiative.

Mr. **Barton**. Mr. Lawrence or Mr. Lee.

Mr. **Lawrence**. We have not, Congressman, but we would expect that these would be pursued through GRI primarily.

Mr. **Barton**. Mr. Lee.

Dr. **Lee**. We as a performer of R&D, the DOE would not discuss their funding mechanisms with us until they become public. But we are aware of their thoughts. We are pleased that they are taking a bigger, better look, deeper look, I guess, on maintaining some kind of a technology base as opposed to the original thought of totally going to a cooperative R&D, which I believe would be a mistake.

Mr. **Barton**. OK. My followup question, which you may have just answered, even though you haven't had much discussion, do you generally agree with the proposal or disagree with it? Dr. Lee, would you say you disagree with it?

Dr. **Lee**. I disagree if it is used to supplant the generic technology building type of support that is required. I do not object to it if it is another avenue being explored. So, we will have to wait and see which way the emphasis is being placed in the coming month.

Mr. **Barton**. Mr. Webb or Mr. Lawrence.

Mr. **Webb**. We generally support it. I think the caution word that Dr. Lee added is, it should never get where it exceeds 15 or 20 percent of the total DOE budget because it's only appropriate for things that are ready to go into the field or where it's ready for an industrial partner. The generic research has to continue. And that cannot be funded adequately under a cooperative venture proposal.

Mr. **Barton**. OK. Mr. Webb, your institute is funded, is self-financed by the gas industry. Are the fees that you receive, are they a constant add-on fee regardless of the price of natural gas? Or are they a percentage of the price? In other words, if natural gas prices go down, do your revenues go down, or do they remain constant?

Mr. **Webb**. The revenues are established two-fold. No. 1, our board of directors, which is made up of the gas industry companies, allows us to propose to the Federal Energy Regulatory Commission on an annual basis a funding unit. Now, that funding unit is a fixed unit. It's not a proportional unit. But our revenues can go either up or down, depending on, No. 1, the action our board takes regarding the amount of funding they think appropriate for the coming year, and then the Federal Energy Regulatory Commission's order.

Mr. BARTON. So, you're basically in the position you make a recommendation on the interstate sales and the FERC approves or disapproves, and on intrastate you go through the various State regulatory commissions. Is that right?

Mr. WEBB. Yes, that is correct. On the interstate sales we propose for our members a funding unit and a program which the FERC and the 50 States, who are automatic intervenors, review and revise and then approve.

On intrastate sales we work through our member companies so that our member company would file in their rate case to recover the GRI funding unit on their intrastate sales. And then it would be up to the individual State commissions to either allow all or part of it or to reject it.

Mr. BARTON. Just a few comments and then I will be happy to turn it back to the chairman.

Mr. Lawrence, I assure you there are some of us that want to repeal the Fuel Use Act. Congressman Hall is not here today, but he's got a bill to do just that; and I am a cosponsor. We are going to be working on that.

Mr. LAWRENCE. That's great.

Mr. BARTON. I would like to point out on the rig count, I think Dr. Lee indicated the rig count is around 1,300. That is a deceiving number because most of those rigs are developing proven reserves in field drilling. To my knowledge, I would make a bet that there are less than 100 rigs in exploratory activities. There may be less than 10. So, we are just drilling what we already know is there. So, it's very deceiving to compare rig counts because 2 or 3 years ago we were out looking for new deposits. Today we are only drilling what we already know is there.

Mr. Lawrence, you referred to natural gas prices being lower. My numbers indicate people that are able to sell gas today are selling it about $1.90 an MCF, somewhere in that range. Assuming that oil prices stay at $12 a barrel, I don't see that the consumer is going to benefit much from natural gas prices because natural gas prices that the consumer pays, the percentage of that at the wellhead is, what, 20 percent of the price that the consumer ultimately pays, something like that? Is that a good number?

Mr. LAWRENCE. That 20 percent, I think, went back to the field price regulation days. I think it's a much higher proportion than that now. But the fact that the spot price is down to around $1.90 is certainly closing the gap in the directions you have in mind.

Mr. BARTON. So, we would not benefit, those consumers that burn natural gas to heat their homes and cook their food, they are not necessarily going to see a big price decline in their gas bill. Is that fair to say?

Mr. LAWRENCE. You had about an 8-percent decline in this winter compared with the previous winter. I suspect we will have at least that much in the coming year.

But again, I think most of that has been the oversupply of natural gas and gas-to-gas competition. I don't really think it has felt the impact of the declining crude oil price. And the only effect that is going to have on the gas price if it does in fact erode our industrial markets. And there are some tradeoffs there.

Mr. BARTON. I guess the last comment in Mr. Webb's testimony indicated that declining domestic production of oil and gas over the next 15 years to about 6 million barrels per day. I talked to a gentleman named Boone Pickens a couple of weeks ago. He knows a little about oil and gas——

Mr. LAWRENCE. I heard that name.

Mr. BARTON [continuing]. Or how to buy it, anyway. And he indicated that, if oil prices go down to $12 a barrel and stay at $12 a barrel for at least a year, that we will lose about 3 million barrels a day of production, just like that. Now, he may be exaggerating a little bit, but that's a lot quicker decline than is indicated in your testimony.

Mr. LAWRENCE. If I could just comment.

Mr. BARTON. Sure.

Mr. LAWRENCE. The severe impact that this is having on the producing State of Texas, my home State of Oklahoma, Louisiana, New Mexico, indeed 35 States that comprise the Interstate Oil Compact Commission, is severe. We hear a great deal about the recessionary impacts that not developing our coal resources have. And indeed those societal impacts are worth considering. But they are severe in the producing States, too.

Now, I have got to take some disagreement with my colleague Dr. Lee in response to Congressman Packard's question: Is coal the future energy resource for this country? I am not sure the returns are in on that at all. That has been conventional wisdom ever since the Arab oil embargo, but it still isn't.

Again, I go back to the point I made. If we even bring to commerciality a third of the geopressure resources, then you're talking about a larger resource base for methane energy. That doesn't include the hydrates or the abiogenic. We're talking about a huge resource base here.

We have already got a current oversupply, just by getting rid of the Federal field price controls. We have got a delivery system that is in place, a million miles of pipeline in all 50 States; it goes everywhere. It's the most efficient environmentally benign delivery system there is. Let's let this research give it a chance to make its long-term energy contribution.

It may well be at least as significant in the long term and more significant than coal or nuclear.

Mr. BARTON. That's all I have, Mr. Chairman.

Mr. FUQUA. Mr. Walgren.

Mr. WALGREN. No questions, Mr. Chairman.

Mr. FUQUA. Mr. Lawrence, in the cogeneration facilities that have been planned and constructed with a wide variety of application, do you have any idea what percentage of that might be from natural gas?

Mr. LAWRENCE. Yes, sir, I think slightly over 50 percent of the planned installations are gas-fueled. It's the preferred fuel.

I might also add that the planned installations on the book, you're talking about 1.3 trillion cubic feet of new market, which would be a very significant addition at a time when the primary disincentive as far as gas producers are concerned is lack of demand.

Mr. FUQUA. David, you talked about a $35 million redirection from the Office of Energy Research. Where would you direct those funds that you are talking about, the $35 million?

Mr. WEBB. Mr. Chairman, I don't think I would. I mean, I think it ought to be a general redirection and not a specific one. If you consider that the programs under the Office of Energy Research have a budget of about $1.8 billion proposed for 1987, then to assume that in $1.8 billion you can't find $35 million to set up a long-term generic research program for enhanced oil and gas, I don't think is reasonable.

I mean, I don't feel qualified to—I would do it a certain way. They do it a certain way. But there is bound to be programs in there that they know could be reduced by 1 or 2 percent to fund this initial effort. So, I think it ought to be a general redirection, not a specific redirection. I would leave it up to the Department.

Mr. FUQUA. You would not specifically recommend that go into geosciences then?

Mr. WEBB. No, no, I'm sorry. I would recommend they establish a $35 million geosciences program, but I would leave it up to the Department as to how within the $1.8 billion they establish the $35 million initiative.

Mr. FUQUA. Yes, within the funds that are available within that——

Mr. WEBB. Yes, and I believe their proposal for 1987 is $1.820 billion. So, we're talking 2 percent of that.

Mr. FUQUA. Bernie, you were talking about $1.3 million for the Walt Disney test facility, biofuels program. It is my understanding that had been jointly funded with the University of Florida and GRI. Why do we need DOE to come into that at this time?

Dr. LEE. That program was indeed, and is, being funded indeed by GRI and the University of Florida. We are working with both on the project. The original goal was to convert water hyacinth at the Disney World to methane to make that community a demonstration community for a totally self-sufficient operation. But in the current program we are adding sewage sludge as a waste disposal system to go along with the hyacinth. I think it has been quite successful.

We feel that DOE in its biofuels program has a program element that concentrates on the utilization and disposal of waste of all sorts. We think it's a logical time for them to join with a program that has been supported by GRI for a number of years, and it's moving along quite well, to expand the use of waste as a feedstock along with the hyacinth experience we already have. Facilities are already in place. It really is a minimal type of cofunding to support a worthwhile waste disposal problem.

We are recommending sludge, industrial wastes, municipal solid waste, and all these things here which can be added to the system for biological digestion.

Mr. Fuqua. Thank you, gentlemen, very much. We appreciate your being here with us today.

[Additional questions and answers submitted for the record follow:]

GRI
gas research institute

1331 Pennsylvania Avenue, N.W.
Suite 730 North
Washington, D.C. 20004-1703
202/662-8935

DAVID O. WEBB
Senior Vice President,
Policy and Regulatory Affairs

March 13, 1986

The Honorable Don Fuqua, Chairman
Subcommittee on Energy Development and Applications
Committee on Science and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

Attached is the GRI response to additional questions from the March 4, 1986 hearings on the FY 1987 DOE fossil budget. I appreciate the opportunity to respond to these questions. If you need additional information, please feel free to contact me.

Sincerely,

David

David O. Webb

cc: Bill Harvey
Attachment

Gas Research Institute, 8600 West Bryn Mawr Avenue, Chicago, Illinois 60631 312/399-8100

1. To what extent would the Gas Research Institute consider providing funds for gasification and hot gas clean-up work at Waltz Mill?

   Currently no GRI money is going directly to Waltz Mill, KRW, or Westinghouse to support this activity although in the past funding was provided by GRI. However, DOE and GRI currently have a joint program in gasification to fund the ash agglomerating program conducted at the Institute of Gas Technology. GRI is currently funding the program but money was never appropriated for DOE's portion. GRI is trying to roll into that joint program an understanding that DOE will bring into the joint program the information from the work being done at Waltz Mill. In other words, GRI would provide timely data on the ash agglomerating project and DOE would provide timely data on the Waltz Mill project. The information coming out to Waltz Mill is certainly of interest to GRI. GRI would take any current information and integrate it into other SNG projects in which it is involved.

   In this regard, rather than a traditional "Joint DOE/GRI Program," it is more of a "Cooperative Program." Both DOE and GRI contribute funds exchange information on results of the different programs.

2. Due to past funding, it would appear that the present effort for surface coal gasification should be directed to basic research, as you mention, including catalysts, materials, components, and instrumentation. The gasification processes themselves seem to be fairly well established. Does it, therefore, seem logical that efforts should be directed to cleanup of gasification products?

   In view of the current concern over the problem of acid rain, it is logical that efforts should be directed to the cleanup of gasification products although not at the expense of the gasification process itself. There is still much to be done and much refining of technology before coal gasification can be economically viable. In addition, the downstream clean up processes determine the engineering configuration of the plant and must be developed as an integrated system.

   Separation and removal of carbon dioxide, sulfurous compounds, ammonia, hydrocarbon liquids, and other gasifier byproducts to produce pipeline-quality gas, commercially valuable byproducts, and environmentally acceptable discharges requires a significant capital investment. Most of the existing processes to perform these functions were developed for technologies other than SNG from coal. Continuing R&D effort is needed to evaluate and develop appropriate technology for streamlining the removal of carbon dioxide and sulfurous gases in conjunction with the development of direct methanation technology. This overall effort to streamline downstream gas processing also requires careful consideration of the engineering requirements for integration of improved processes into coal gasification plants. The downstream processes constitute 30% to 35% of the total installed plant cost, so improvements can provide significant savings in plant investment and gas production costs.

RESPONSE OF THE AMERICAN GAS ASSOCIATION
TO SUPPLEMENTAL QUESTIONS FROM
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES
ON THE FY 1987 DEPARTMENT OF ENERGY
RESEARCH AND DEVELOPMENT BUDGET

APRIL 7, 1986

1. You mentioned liquified natural gas safety, but not the test facility in Nevada. Are you familiar with that facility, and if so, what benefits does it provide for your industry?

I am very familiar with the Nevada facility. The Liquified Gaseous Fuels Test Facility will allow researchers, on a user fee basis, to evaluate spills of liquified gases, including LNG, at magnitudes far greater than has been previously possible. The research needs include investigating equipment vulnerability to natural forces, the ability of dikes to contain large spills, the advantges of in-ground storage, the behavior of spills on different surfaces and the validation of methods for preventing accidental liquified gaseous fuels spills.

2. What amount of the biomass program should be devoted to the production of feedstocks and what proportion should be devoted to conversion process development?

The Department of Energy should direct approximately 75% of its Biomass resources to conversion process R&D. We are very pleased with this Subcommittee's recommendation of $16.3 million for thermochemical and biochemical conversion work and $5.2 million for production research in FY 1987.

ADDITIONAL QUESTIONS FOR THE RECORD

Dr. Bernard S. Lee:

1. What processes do you believe must be investigated to realize the greatest economic benefits from the Eastern Oil Shale resouces?

It has been increasingly recognized over the last few years that the eastern oil shale resource is unique. For the most complete, economical utilization of the resource, a process which has been specifically developed for eastern oil shale is necessary.

The results of a DOE-sponsored study performed by Los Alamos National Laboratory indicated that the HYTROT process is the economically preferred method for eastern oil shale retorting. The study, entitled "An Economic Comparison of Five Process Concepts for Using Eastern Oil Shale" compared two versions of the HYTORT process, two versions of the Paraho process and the TOCSO process. In addition to its preferred economics, it was concluded that the HYTORT (pressurized hydroretorting) process has technical advantages as well. Research funding should be made available to continue to improve the pressurized hydroretorting economics.

In conjunction with pressurized hydroretorting research, further research on eastern oil shale beneficiation should be conducted. Although the beneficiation process per se does not produce oil, it provides a greatly enriched feedstock for subsequent retorting. For example, an eastern oil shale which would produce approximately 12 gal/ton with conventional processing was beneficiated and processed in a test pressurized hydroretorting unit to yield over 55 gal/ton.

These promising experimental results strongly indicate that further research should be conducted on both pressurized hydroretorting and beneficiation of eastern oil shales.

2. If a contaminant resistant molten-carbonate fuel cell could be developed, what would be the advantage of that process over the solid oxide fuel cell?

According to a report prepared by DOE's Advanced Fuel Cell Working Group, current molten carbonate fuel cells are superior to solid oxide fuel cells. Molten carbonate fuel cells enjoy advantages over solid oxide fuel cells in the areas of:

a. higher efficiency - molten carbonate fuel cells have approximately a seven percentage point efficiency advantage over solid oxide fuel cells (49% vs 42% efficiency). This means that a power plant would use 17% less fuel to produce the same amount of electricity using the molten carbonate fuel cell.

b. lower costs - for a generating plant producing 300kw of electricy, the cost for a molten carbonate fuel cell is $1060/kw while that for a solid oxide fuel cell is $1716/kw (65% higher).

c. less complex construction and higher reliability - the maximum power output of a solid oxide fuel cell is 15 watts/cell. Molten carbonate fuel cells are being produced which should produce 1200 watts/cell. This means that a solid oxide fuel cell will need approximately 80 times as many parts, electrical connections, gas connections, etc. as will a molten carbonate fuel cell. Each additional part and connection is an additional complication and point at which a failure could occur.

The contaminant resistant molten carbonate fuel cell is expected to retain all of the benefits of the standard molten carbonate fuel cell and have the followig additional advantages:

a. The contaminant resistant molten carbonate fuel cell will be able to operate on sulfur and chloride containing fuels without performance loss. This performance loss can occur by chemical reaction of the contaminants with the materials comprising the fuel cell and/or coating the fuel cell materials thus preventing the fuel from reacting in the fuel cell. While solid oxide fuel cells are less prone to reaction of the sulfur with fuel cell materials, it is believed that SOFC's will be more sensitive to coating/absorbing of the contaminants because of the smaller surface area of solid oxide fuel cell.

b. Materials costs for the contaminant resistant molten carbonate fuel cell are expected to be 30% lower than for the standard molten carbonate fuel cell. This means that contaminant resistant molten carbonate fuel cell materials will cost 70% less than the materials for the solid oxide fuel cell.

Mr. **Fuqua**. Our next panel is Dr. Gene Mannella, Electric Power Research Institute; Dr. George F. Mechlin, vice president, Westinghouse Research and Development; and Michael Koleda, president of the Council on Synthetic Fuels.

Dr. Mannella, we would be pleased to hear from you at this time.

STATEMENTS OF DR. GENE G. MANNELLA, ELECTRIC POWER RESEARCH INSTITUTE; GEORGE F. MECHLIN, VICE PRESIDENT—RESEARCH AND DEVELOPMENT, WESTINGHOUSE ELECTRIC CORP.; AND MICHAEL S. KOLEDA, PRESIDENT, COUNCIL ON SYNTHETIC FUELS

Dr. **Mannella**. Thank you very much, Mr. Chairman.

We have prepared a statement which we would like to have inserted in the record in its entirety.

Mr. **Fuqua**. Yes, without objection, all the statements will be put in the record in their entirety.

Dr. **Mannella**. We appreciate this opportunity to appear before the subcommittee today to discuss the EPRI R&D Program, as it relates to the Department of Energy's fiscal year 1987 budget request for fossil energy R&D. Our testimony today has been developed with the aid of a number of EPRI Program offices but is principally based on the work directed by Kurt Yeager, vice president and director of the Coal Combustion Systems Division, who has appeared before this subcommittee many times.

EPRI, as you know, was established by the electric utility industry in 1972 to plan and implement a broad research and development program for the industry and its ratepayers. EPRI is supported by voluntary contributions from investor-owned, government-owned, and cooperatively-owned electric utilities across the entire United States. These contributions support a program on the development of new technologies for electric power production, delivery, and efficient utilization.

Mr. Chairman, EPRI is no stranger to this subcommittee and has enjoyed many opportunities to meet with you to discuss items of importance for the national energy R&D effort. Because the bulk of the coal produced in this country is used by utilities to generate electric power, EPRI has a strong interest in all phases of coal utilization. Further, over the years, EPRI has developed an excellent working relationship with the DOE Office of Fossil Energy. This has resulted in close cooperation and sharing of research results. It is therefore very appropriate that we appear here today. We do so mindful of the fact that the administration has requested substantial fiscal year 1986 deferrals and a fiscal year 1987 budget that is significantly lower than the 1986 appropriation. We hope that our testimony will provide some guidance to the Congress as it makes the difficult budget decisions that lie ahead.

Over the past 5 years, EPRI and DOE have worked together cooperatively to jointly plan programs and exchange research results. As a consequence, there are a number of DOE programs in the fossil area in which we have invested complementary funds. By this I mean we have shaped our program and expenditures to anticipate the application of results from the longer term DOE program. A good example of this is in the coal cleaning area, where EPRI has put into operation a Coal Cleaning Test Facility, in Homer City, PA. This facility currently uses state-of-the-art techniques to clean coal sent by utilities, burn it, and then measure its physical parameters and emissions. By virtue of a memorandum of understanding with DOE, the more advanced technologies supported by the department will be tested at this facility as they become ready for evaluation, saving the Government the expense of building a suitable test unit. This and many other similar activities are outlined in our formal testimony.

As I stated earlier, EPRI depends on dues paid by over 500 electric utilities to support an R&D program, which last year was slightly less than $300 million. Our R&D program in 1986 will total less than $250 million, which is down $50 million from the previous year then. This reduction occurs partly because of the loss of dues from several utilities that have experienced financial problems with the completion of nuclear generating capacity and partly because of adjustments between authorization and outlays.

Further, we expect our budget to be flat for several years. This comes at a time when the Federal budget support for R&D is facing downward pressure because of the deficit in general and Gramm-Rudman-Hollings in particular.

My message then is that your job isn't any easier in that the private sector cannot at this time take up any slack in Federal funding.

With regard to the question that you asked in your letter of invitation on the impact of GRH, Mr. Chairman, trying to unravel the interconnections between the 1986 budget, Gramm-Rudman-Hollings, and the fiscal year 1987 submissions is rather formidable. We are somewhat confused and not a little disappointed about the fiscal year 1986 deferrals requested by the administration. If our understanding is correct, the implementation of the deferrals would make most of the discussion of fiscal year 1987 moot, since so many of the programs would have been phased out. In other words, it's difficult to try to optimize 1987 when the 1986 deferrals are unresolved. Further, we are not at all clear what the magnitude of what the 1987 Gramm-Rudman-Hollings cuts may be, and whether they will be automatic or discretionary. Nevertheless, we have tried to come up with a constructive response to your request by examining two possibilities.

The first alternative or the first possibility, albeit extreme, is the administration's fiscal year 1987 budget proposal, what we might characterize as a deep horizontal cut. Suffice it to say that, as pointed out in our prepared statement, the program proposed by the administration would seriously damage the national R&D program in fossil energy.

The other alternative is to find a way to continue the fiscal year 1986 program as merited, with no more than a small horizontal cut. We think that the program reflected in the fiscal year 1986 appropriation enacted by the Congress is a fair one. If belt tightening must occur, we suggest that an overall markdown of fiscal year 1986 along the lines of the percentage amount anticipated for Gramm-Rudman-Hollings be the starting point. The markdown should not, however, be across the board, since there are cases where a program has reached its logical termination point, or where some shift in emphasis could be accommodated in competing technologies within a given program element. By deleting activities that end in fiscal year 1986 plus some judicious scaling back where necessary, it should be possible to continue the 1986 program on through 1987 but at a total funding somewhat below the 1986 level. This would accommodate the intent of Gramm-Rudman-Hollings but in any given program element would amount to a reduction of perhaps a few percent at most. This is preferable to the across-the-board approach of Gramm-Rudman-Hollings and the administration's proposal.

One final comment we would like to get on the record, Mr. Chairman, is in regard to the venture pool concept. While initially intrigued, we were not able to make any clear determination of the potential this concept holds for us. One disturbing aspect is that in the case of the fossil energy budget these moneys would be made available for resource recovery activities at the expense of coal R&D. This would fly in the face of the letter of the administration's budget submission and the generally regarded high priority needs for coal research and development.

EPRI has within the past several years aggressively promoted a center-of-excellence concept, which might serve as a useful model for the venture pool initiative in the DOE budget. In the spirit of cooperation we are willing to explore possible collaboration of this type of activity. We have begun a dialogue with some of the DOE offices that might be involved in this program in the hopes of establishing a rapport that might develop into a mutually beneficial program.

We would encourage the department to discuss the concept fully, perhaps in a seminar setting with all of the potential participants before attempting its implementation. But the point that we are particularly concerned about is that the funding for this venture experiment should not be made available at the expense of either ongoing fossil R&D or, by substitution, the clean coal technology program.

This concludes my remarks, Mr. Chairman. I would be happy to answer any questions that you might have at this time.

[The prepared statement of Dr. Gene Mannella follows:]

STATEMENT OF KURT E. YEAGER, VICE PRESIDENT AND DIRECTOR, COAL COMBUSTION SYSTEM DIVISION, ELECTRIC POWER RESEARCH INSTITUTE AND GENE G. MANNELLA, DIRECTOR, WASHINGTON OFFICE, ELECTRIC POWER RESEARCH INSTITUTE

Introductory Statement

Mr. Chairman, Members of the Subcommittee:

We appreciate this invitation to discuss the FY87 DOE Fossil Energy Research and Development programs and its corollary activity the Clean Coal Technology Program. These programs have significant implications for the electric utility industry and therefore are of great importance to EPRI.

The Electric Power Research Institute was established by the electric utility industry in 1972 to conduct a broad research and development program for the entire electric utility industry and its rate payers. EPRI's R&D mission is to develop new and improved technologies for electric power production, delivery and use, and to help accelerate their availability to insure an adequate supply of economic, reliable and environmentally acceptable electricity.

EPRI is supported by voluntary contributions from investor-owned, government-owned and cooperatively-owned electric utilities across the nation. Over one-third of EPRI's planned budget over the next five years will be directed to clean coal utilization. This is an addition to the $500 million already invested by EPRI on this effort. This commitment is based on the premise that coal utilization and environmental protection are mutually compatible and that improved technology is the key to compatibility. Sound scientific data derived from independent, peer-reviewed research must be developed in a timely manner on topics of environmental concern. In addition, information is required to reliably apply the most cost-effective clean coal technologies meeting the diverse needs of the utility industry.

Current environmental control capabilities must also be improved by reducing capital and operating costs and preserving overall plant productivity. The importance of this effort is underscored by the fact that approximately 40% of the capital investment and 30% of the total cost of power for new, conventional coal-fired power plants are related to environmental control. This includes sulfur dioxide (SO_2) scrubbing, particulate control, solid waste disposal, water treatment and plant cooling. These controls in their current form have a major impact on plant efficiency and reliability. Closely associated with this issue is the increasing difficulty in siting new utility and other energy facilities.

Since its inception, EPRI has worked with the Department of Energy (DOE) and its predecessor agencies, the Environmental

Protection Agency, and other Federal agencies with energy research and development responsibilities to achieve mutual technical objectives. In the spirit of that long-standing cooperation, EPRI and others recommend an accelerated national program to better understand the environmental issues constraining the use of coal and to develop, demonstrate and promptly apply improved, clean coal technology. This effort would build on activities already underway within the Federal and private sectors. The February 1986 DOE Program Opportunity Notice for Clean Coal Technology Demonstration Projects is reflective of this recommendation.

The Need for Technology

The utility industry stands at a threshold of fundamental change in its technological base for power generation. The present commercial technology is nearing the end of its development potential and is increasingly hard-pressed to respond to the rapidly changing requirements being placed on the industry. New options which can meet increasingly stringent siting and environmental demands without sacrificing productivity, and can be rapidly constructed in modular fashion over the range of unit sizes are particularly in demand. The next 10 years will therefore be of paramount importance, both in assuring future electricity supply and in controlling cost. Coping with this transition will require an intensive partnership commitment on the part of the utility industry, its suppliers, and government.

Issues Facing the Private Sector

The role of the private sector in carrying out clean coal technology R&D must reflect the unique aspects of the primary using industry-the electric utilities, and their technology suppliers:

- The electric utility industry is a financially regulated industry. Rates of return are governed by public utility commissions, and therefore, profits do not necessarily reflect risks.

- The immediate financial problems facing many utilities and their inability to generate capital funds for improvement or expansion makes additional R&D funding even more difficult. As a result, EPRI is able to fund less than half the scope of its program at a time when the needs are increasing dramatically.

- Major financial risk is associated with incorporation of innovative technology into an established and complex electric power system so that it is economical and reliable.
- Utility suppliers cannot be assured of a sufficient return on R&D investment to maintain technical leadership in the current limited domestic market situation. R&D is only the first step which, if successful, will require time and much greater expenditures for engineering, manufacturing, marketing and capital before a profit is realized. The possibility of changes in government policies over this period further amplifies the risk.
- Foreign countries, where a more cooperative partnership between government and industry has been sustained, are aggressively moving to assume leadership in the development and commercialization of improved coal utilization technology.
- Loss of technological leadership may force the utility industry and its suppliers to depend on these foreign sources. Other, far-reaching implications for supplier confidence and the U.S. international position are self-evident in such foreign dependence.

Technology Options

The inefficiencies and costs of current flue gas desulfurization technology coupled with the uncertain possibility that existing plants may require retrofitting of emission controls leads to the need for additional, simplified emission control options. These range from improved physical coal cleaning to low NO_x combustion, furnace sorbent injection, and dry scrubbing. No single one of these options will satisfy the widely varying conditions in the range of existing coal-fired utility and industrial power plants. As a set, however, they can reduce the cost and productivity limitations of emission control today.

Selection will depend on a number of variables including control requirements, cost and functional criteria such as plant design and space limitations. Functional criteria can be a particularly important constraint when considering retrofit to existing plants. Unlike new plants where the boiler and emission controls can be designed as an integrated unit, retrofit requires adaption to a plant not designed for such modification. This can lead to compromise and additional expense.

The more effective alternative is the use of new coal utilization technologies such as fluidized bed combustion (FBC) or gasification combined cycle (GCC). These technologies combine emission control within the combustion or conversion process. The result is both greater emission control efficiency and improved generation productivity to fundamentally resolve perceived conflicts between energy and the environment. This underscores the value of economic and regulatory incentives that encourage prompt transition to these improved coal utilization options.

The principal appeal of these technologies is that they directly address the major factors affecting coal-fired power generation - notably, emission control. Combining emission control with the combustion or conversion process is inherently less costly and more efficient than removing pollutants from the flue gas. As a result, they are a more effective alternative for an industry facing the possibility of mandated additions of flue gas desulfurization systems to current coal-fired capacity.

The most effective national coal utilization program therefore should have four major objectives. Based on the existing development foundation, all four objectives can be achieved within the next five years. It will require, however, a major, joint private/Federal effort to share the costs and risks, particularly at the technology demonstration scale.

- Establish a sounder scientific base to guide the nation on the needs and appropriate timing of emission controls.
- Develop and demonstrate the array of potentially more effective retrofittable emission control alternatives to current flue gas scrubbing technology.
- Develop and demonstrate the advanced coal utilization technologies, e.g. atmospheric fluidized bed combustion, pressurized fluidized bed combustion, and gasification combined cycle, over a sufficient range of conditions to establish performance, cost, and reliability.
- Establish incentives to encourage the prompt commercial implementation of these technologies.

The Role of DOE

EPRI strongly endorses the DOE Clean Coal Technology program mandated by P.L. 99-190, which will make available $149.1 million in FY1987 for cost-shared demonstrations. This is the most essential ingredient today in accelerating the utilization of clean coal technology. We support the intent of Congress that DOE's role be as a risk-sharing investor, not a loan office which would be of little value to the regulated utility industry who will lead many of these necessary demonstrations. We are, however, very concerned that this new program is financially more than offset by the $229.2 million reduction in the FY1987 DOE request for the Fossil Energy Research and Development program. This represents a 73% funding decrease in this important program. The reductions by R&D category are summarized below:

		Budget Reduction 1987 vs 1986
-	Control Technology and Coal Preparation	44%
-	Advanced Research and Technology Develop.	20%
-	Coal Liquefaction	72%
-	Combustion Systems	68%
-	Fuel Cells	85%
	Heat Engines and Heat Recovery	36%
-	Underground Gasification	100%
-	Magnetohydrodynamics	100%
-	Surface Coal Gasification	86%

The proposed reductions eliminate or decimate nearly every category of clean coal utilization R&D. Of particular note is the major reduction in Combustion Systems at a time when direct, clean combustion of coal must be increasingly relied upon to sustain electricity supply and economic growth. The precipitous decline in all categories of applied clean coal R&D is inconsistent with the technical foundation necessary for DOE's strategic objective to "increase the contribution of coal through improvement in environmental, technical and economic performance and increase the number of areas of applicability and flexibility of use on coal-based systems." The overall DOE program is only able to touch a few relevant technical areas.

DOE's proposed initiative to leverage Federal funds through cost-sharing cooperative ventures in fossil energy R&D is, in our judgement, likely to result in far more cosmetic than actual offset of this drastic DOE budget curtailment. One fear is that making funds available for this initiative from meager R&D funds may result in pressure to tap other programs to make up deficiencies. EPRI would therefore further recommend that funds not be diverted from the Clean Coal Technology Program to make up any funding deficiencies in the Fossil Energy R&D program. These programs are complementary but entirely separate in scope, risk and management requirements.

AVAILABLE

Additional resources for specific activities under the DOE Fossil Energy R&D program should be given priority consideration on their own merit. They provide the essential technical underpinning for the Clean Coal Technology program and DOE's strategic objectives. Specific recommendations in this regard are summarized in the concluding section of this testimony.

DOE does have a unique opportunity to work closely with the private sector to resolve the various constraints, often resulting from governmental action, on the nation's use of coal. In this context, cofunding is only one way in which DOE can help. DOE should also lead, when opportunities arise, in program which could result in increased private sector R&D efforts and reduce the need for direct DOE involvement. For example the state of Ohio has recently taken the initiative of funding programs in that state in such a way that the utilities--the industrial partner--are basically the leaders and the state role is to promote demonstrations by underwriting part of the cost.

Finally, leadership also calls for stability of program and purpose, especially where cofunding is involved. A prime concern of private sector R&D management is that program direction and budget, once adopted, will not be changed arbitrarily. This is particularly important to multi-year projects where change in direction is costly and wasteful. Improved stability would facilitate commercialization of improved coal technology.

Conclusions and Recommendations

Detailed observations on the scope of the DOE Fossil Energy R&D program and the priorities and emphasis reflected in the 1987 budget request are contained in the Appendix A. EPRI's primary conclusions and recommendations are summarized as follows:

- Coal quality improvement and control is central to the efficient, reliable and environmentally acceptable performance of coal-fired utility power plants. Further, the quality of the coal feedstock will be a critical factor in realizing the economic benefits of advanced coal utilization technology such as coal gasification and fuel cells. The national research program should put a high priority on:
    - Techniques for improving the slagging and fouling characteristics of lower rank Western coals.
    - Efficient and economical physical cleaning and dewatering of fine coal.

- Economically feasible chemical cleaning techniques to improve sulfur and ash removals.

- EPRI supports the continued DOE activities in advanced physical coal cleaning at the EPRI Coal Cleaning Test Facility. However, the magnitude of the cuts in Coal Preparation in the DOE budget request will delay or sacrifice the achievement of the other high priority technology goals listed above, notably fine coal dewatering technology. EPRI's research is the only other national scope program in coal preparation and will be unable to fill the gap if the DOE program is curtailed.

o Retrofit of modified design, low NO_x burners to existing power plants offers the lowest cost approach for reducing NO_x emissions. Present DOE involvement is limited to fundamental research in the chemistry and physics of NO_x formation, post-combustion NO_x removal systems and simultaneous SO_2/NO_x removal processes. EPRI's view is that combustion NO_x control techniques should be pursued as a more cost-effective NO_x control approach. Accelerated R&D is necessary to assure the success of field demonstration programs planned jointly by industry and government.

o High priority should be placed on resolving the reliability, by-product disposal and cost issues impeding the effectiveness of flue gas desulfurization (wet scrubbing) applications to existing, high-sulfur coal-fired plants. A high leverage opportunity for Federal funding to address these issues is participation in the High Sulfur Test Center. This facility is now under construction in western New York by a consortium of EPRI, New York State Electric & Gas Company, New York State Energy research & Development Authority and Empire State Electric Energy Research Corporation.

o EPRI research has shown that in-boiler sulfur oxides control via sorbent injection is a relatively low cost, near-term approach that can reduce SO_2 emissions by 50% or more at many existing plants. This technology is ready for prototype testing to define the impacts of the process on performance and reliability of the boiler, particulate control equipment and waste disposal. Utilities, EPRI, and the Environmental Protection Agency are planning two such prototype test programs. At least four additional prototype tests will be required to cover the range of boiler types coals and injection techniques that should be considered. The DOE 1987 budget request is not adequate to insure the technical foundation for these projects.

- The DOE budget request for waste management research is limited to the completion of several on-going efforts, primarily in the sampling and characterization of organic and inorganic species in wastes from emerging technologies. A major new EPRI project in management of solid waste by-products from advanced SO_2 control technologies provides an opportunity for coordination of the EPRI and DOE programs. Little attention has been given to date to the secondary pollution questions associated with the by-products of spray-dry flue gas desulfurization, atmospheric fluidized bed combustion, injection of limestone into a furnace, dry sodium addition and advanced physical coal cleaning. Reducing DOE involvement to only a sampling and characterization role is to abandon any meaningful Federal presence in an area which may be critical to the broad implementation of the emerging advanced coal technologies.

- Fluidized bed combustion offers several advantages over conventional fossil-based power generation - notably, fuel flexibility, inherent SO_2 and NO_x control and load following capability. The U.S. utility industry through EPRI has brought atmospheric fluidized bed combustion (AFBC) technology to commercial demonstration use by electric utilities. Federal agency participation in the 20 MW TVA/EPRI AFBC pilot plant and the full-scale TVA/Duke Power/Kentucky/EPRI AFBC demonstration has been essential to the success of this effort.

  The FY1987 budget request unfortunately eliminates further DOE participation in improving AFBC for broad utility use and relegates the federal government to expanding markets in the light industrial and commercial sectors. EPRI urges continued DOE involvement in AFBC as a power generation alternative that fits all of DOE's program criteria: a high probability of commercial success, significant private sector participation, international interest and cooperation and heavily cost-shared programs.

- Pressurized fluidized bed combustion (PFBC) offers the advantages of AFBC plus the potential for a smaller unit size, higher efficiency and better utilization of SO_2 sorbent. EPRI has focused on the PFBC turbocharged boiler as an approach that is well suited to shop-fabricated modular construction and is thus attractive for reducing construction schedules and cost.

In support of the demonstration of this technology, EPRI and DOE plan soon to commit an aggregate of $10 million toward hot gas cleanup filtration and coal slurry feed tests at the Grimethorpe, England facility operated by the Central Electricity Generating Board and the National Coal Board. The U.S. participation in these tests is essential not only to obtain large scale confirmation of ceramic filter performance and durability at realistic utility power plant conditions but also to leverage the U.S. investment by gaining access to all testing results. These results are essential to confident implementation of the PFBC demonstration projects being proposed under the DOE Clean Coal Technology Demonstration Program.

- The DOE 1987 budget request is aimed at continuing the Grimethorpe testing and additional gas filter testing at New York University. EPRI fully supports these efforts and has recently cut back other programs in order to maintain the planned commitment to the Grimethorpe testing. EPRI further urges that the New York University tests be extended beyond the 250 hours planned operating time on each gas filter. Work in pressurized combustion phenomena under the AR & TD Direct Utilization activity should also be continued and expanded.

- In 1985 EPRI sponsored a study of the feasibility of converting Wisconsin Electric Power Company's Port Washington #5 unit to a PFBC turbocharged boiler. EPRI views this as a particularly attractive candidate for funding under the Clean Coal Technology Program. The results will provide the basis for the most cost-effective repowering/life extension option available to the utility industry in the 1990's. This will both protect existing high sulfur coal utilization and expand it into oil-fired plants, as well.

- Priority should also be given to a joint federal/private effort to establish a circulating PFBC pilot facility in the U.S. to develop the engineering foundation for future demonstration of this promising technology.

- A second PFBC demonstration project is also recommended as a bridge between PFBC and IGCC technologies which marrys advantages of both. The result is a system that has promise of being both simpler and less expensive than other coal-based, combined cycle approaches. In this approach, a refractory lined PFBC operating at sub-stoichiometric conditions gasifies coal. The low Btu fuel gas is then cleaned by dry scrubbing techniques and burned in a gas turbine. A 50 MW prototype module of this technology could be effectively implemented under the DOE Clean Coal Technology program and would build on development efforts initiated through the DOE Morgantown Energy Technology Center. The result would open up new opportunities for very clean, lower cost, coal-based energy for electricity production and process steam.

- Fuel cells are modular, environmentally acceptable power plants that offer efficient use of petroleum and natural gas in the near-term and coal-derived fuels in the long-term. Phosphoric acid fuel cells can achieve commercial status by 1990, but commercial success will depend on continued technology improvements to achieve the reliability and costs necessary to penetrate the market. EPRI plans continued support of the development and commercial introduction of phosphoric acid fuel cell power plants during 1986-1990. The elimination of phosphoric acid fuel cells in the DOE budget request threatens the on-going program and would sacrifice the benefits of the progress made to date made under the coordinated support of DOE and EPRI.
- In recent years EPRI has had a modest R&D program in open cycle magnetohydrodynamics, focusing on the MHD channel-inverter interface and power conditioning of the inverter output for electric utility application. A substantial continued Federal investment in MHD is warranted over at least the next 3-5 years to carry out a fully integrated system test of the technical and commercial potential of open cycle MHD technology.
- Partial conversion of synthetic gas to methanol in an integrated coal gasification/combined cycle power plant to produce methanol as well as electricity is economically attractive, according to EPRI studies. EPRI has sponsored planning and engineering studies for a demonstration of this technology at an existing TVA gasifier as the next logical step following a successful DOE-sponsored 40-day process development unit run in 1985. The demonstration at TVA is an attractive candidate for funding under the Clean coal Technology Program.

Mr. Chairman, this concludes our summary statement. The attached Appendix A provides additional detail on many of the points outlined above.

EPRI appreciates the opportunity to present testimony before this sub-committee and hopes that our imputs provide some assistance to the members as they address the very difficult problems of both reducing the national deficit, but at the same time providiing for the necessary Federal assistance required to maintain a strong technology base.

APPENDIX A

EMERGING CLEAN COAL TECHNOLOGIES

An enhanced Clean Coal research, development and demonstration program represents an important need because of the nation's limited ability to develop and apply superior clean coal technology. The present lack of adequate funding mechanisms to demonstrate the reliability, economics and performance of new coal technology is a source of national concern. While private sector efforts have been maintained, they are insufficient in the face of declining incentives for additional private investment. As a result, there are a number of key coal based technologies where the funding to achieve prompt development and demonstration is not evident. This may have profound consequences for the 1990s when new electric generating demands, which must rely on coal, collide with the growing environmental ethic of our society. Emerging clean coal technologies that can benefit by an accelerated Federal and private sector effort are described below.

A. Control Technology

1. Coal Preparation

Coal quality improvement and control is central to the efficient, reliable, and environmentally acceptable performance of coal-fired utility power plants. Coal quality improvement technology will also be a critical factor in realizing the economic benefits of many advanced, coal-based energy conversion technologies, such as coal gasification and fuel cells. Many advanced energy conversion processes are more sensitive to coal quality and variability than current technologies. For these processes, the economic trade-offs between the cost of coal upgrading and process capital and operating cost savings strongly favor appreciable levels of coal cleaning.

Recently, coal cleaning--largely using technology developed in the late 1940s--has become increasingly important to the electric utility industry in their efforts to reduce electricity cost. This technology, which requires low capital expenditure compared with generating plants is being increasingly applied to remove sulfur and ash, reduce coal heating value variability, and improve combustion characteristics. Statistics recently released by the Department of Energy for 1983 indicate that nearly 70% of the coal burned by utilities east of the Mississippi was physically cleaned.

This represents a large increase from 1978, the last year before 1983 that such statistics were collected, when only 45% of eastern steam coal was cleaned. Coal cleaning is clearly a major response of the utility industry to environmental regulations and can reduce fuel cost through increased coal purchasing flexibility. Priority objectives for research and development to improve coal quality and quality monitoring and control include:

- Improved sampling and analytical procedures to insure confidence in quantity and quality estimates from in-situ reserves for power station coal feed.
- Techniques for improving the slagging and fouling characteristics of lower rank, Western coals.
- More efficient and economic physical fine coal cleaning and dewatering technology.
- More economic chemical cleaning techniques providing for high levels of sulfur and ash removal.
- Automated cleaning process control and on-line continuous measurement techniques to improve reliability and product quality.

To support the electric utility industry's need to improve coal quality, improve cleaning processes energy recovery, and reduce cleaning cost, EPRI has operated for the past three years a unique coal cleaning R&D facility; the EPRI Coal Cleaning Test Facility (CCTF). Major goals of this 20 ton per hour test facility are to:

- Characterize the cleanability of U.S. steam coals.
- Develop and demonstrate new and improved coal cleaning technology.
- Develop a national coal quality data base to improve commercial coal cleaning plant design and operations.
- Develop and demonstrate new coal cleaning process instrumentation and control systems.
- Provide practical training for coal cleaning engineers.

A major project initiated at the CCTF in 1985 is a joint Department of Energy and EPRI effort to test advanced physical coal cleaning processes. Under this project, two novel high performance advanced processes will be tested. Process test modules will be operated at approximately one ton per hour, and will test a wide range of U.S. coals. The Department of Energy will perform combustion tests both on the raw coals feeding the processes and the product coals to evaluate the changes in combustion characteristics, and in the nature of the ashes produced by combustion.

Two processes have been selected for testing under this joint advanced physical coal cleaning assessment project. This selection is in response to a DOE solicitation. These are a micro-bubble flotation process (contractor: Bechtel Group, Inc.) and dry electrostatic cleaning (contractor: Advanced Energy Dynamics). Agreements were signed with the two contractors by the Department of Energy in September, 1985. EPRI is currently initiating engineering of the modifications to the CCTF to receive the process test modules, provide them with services, feed them with coal, and remove the product and refuse.

Additional cooperative R&D, to better match limited resources with the potential energy cost savings, is desirable between EPRI and DOE and also with the coal industry, an industry which traditionally has not supported R&D. To date the U.S. coal industry has not become a force in coal quality research and development. This absence is a great weakness when it comes to transferring technology, because it will predominantly be up to the coal industry to use coal cleaning advances. There is a limited and largely informal use of industry experts on advisory committees by EPRI and DOE. However, for a great improvement in new clean coal technology a mechanism for increasing R&D support in the coal industry for clean coal and general coal quality work should be found. The demands of environmental protection offer an excellent opportunity to the coal industry to add value to their product and increase their profitability. It would be unfortunate if their short-term cash flow weaknesses removed the opportunity.

2. Flue Gas Cleanup

a. Flue Gas Desulfurization (FGD)

The highest priority should be placed on resolving the reliability, by-product disposal and cost issues impeding the effectiveness of Flue Gas Desulfurization (FGD) for use on high sulfur coal retrofits.

Federal participation is especially encouraged at the High Sulfur Test Center currently under construction in Western New York State. This center will help resolve chemistry, reliability and materials problems with existing FGD systems and reduce the cost and reliability impact of potential retrofit scrubbers. This industry initiative now has funding of $20 million for construction and over $20 million for operation from EPRI, New York State Electric & Gas, New York State Energy Research & Development Authority and Empire State Electric Energy Research Corporation. Additional funding from U.S. and foreign utilities, coal companies, and other sources is now being solicited. Modest federal funding could be structured in a manner similar to the successful EPRI/DOE advanced coal cleaning development project at the EPRI Coal Cleaning Test Facility.

Simplified and improved FGD processes developed by the private sector, such as the Chiyoda 121 Process, also deserve DOE support. These processes will likely be proposed as part of the clean coal technology solicitation process. This support should not be limited to processes that are 90% efficient. DOE has contracted for development of low-cost retrofit technology with lower removal efficiency in the last year, and this effort should be expanded where there is a matching industry initiative.

A final area of flue gas cleaning requiring additional Federal attention is particulate control technology improvement. All of the technologies to reduce SO_2 emissions from coal cleaning to scrubbers, will have a major impact on the quantity and quality of particulate matter to be collected. Present electrostatic precipitator technology lacks the flexibility to adapt to these new conditions without substantial losses in collection efficiency unless an intensive development and testing effort is initiated.

Demonstration of a combined SO_x/NO_x removal system within the next five years is speculative. Although DOE is today supporting development of several such technologies including the Sulf-X and E-Beam processes, these are still at relatively small scale and a preliminary stage of development. They are unlikely to achieve sufficient performance or cost confidence within the near future to justify large prototype facilities. Increased funding for smaller pilot scale development would probably be more effective within this time frame.

b. Low NO_x Combustion Systems

This too is an area of importance where DOE is not currently involved, at least not beyond fundamental research into the chemistry and physics of NO_x formation. Although DOE is exploring flue gas cleaning systems that reduce this pollutant, the NO_x issue requires accelerated attention in the near term by the development of modified burners that can reduce NO_x substantially (i.e., 50-75%). Such techniques offer the lowest cost approach to reduce NO_x emissions, as well as acid rain precursors if NO_x credits are allowed. While it appears that many coal-fired utility boilers could be retrofitted with low NO_x burners, the different flame shape and specific geometric and mechanical requirements of these new systems can represent significant changes for existing equipment. In addition to these boiler engineering issues, the potential operational and reliability impact of low NO_x burners retrofits must also be addressed through large demonstration tests.

Low NO_x burners are designed specifically for a given boiler type, and commercial scale units for the two boiler types (wall- and tangential-fired) representing the largest installed capacities in the United States are ready for field demonstration. Other boiler types have a significant impact on emissions due to their uncontrolled NO_x emission rates. EPRI is working with vendors to develop low NO_x combustion modification systems for two of these types (units with cell burners and cyclones). An improved cell burner is now ready for field testing, and a lower NO_x cyclone system may be demonstrated at the pilot-scale by 1988, at which time it should be subjected to field trials.

To prepare the utility utility in the event of retrofit NO_x requirements, EPRI is working with utilities and vendors to plan low-NO_x burner field demonstrations for each major boiler type. Although we are discussing a jointly sponsored field demonstration with EPA, that project would address just one burner/boiler type. Because the remaining demonstrations will rely on outside funding of $1-3 million per site for equipment modifications, they will not occur unless the private sector and federal government share these funds. It is unlikely that the private sector will commit enough resources to complete these essential demonstrations.

Advanced NO_x combustion control concepts are also being developed that may produce further NO_x reductions of up to 50%. Much of this development has taken place in Japan, but EPA, EPRI, the Gas Research Institute, and several boiler vendors have initiated laboratory activites to translate the technology to U.S. conditions. These "reburning" or over-firing techniques should also receive increased development and demonstration attention.

c. Furnace Sorbent Injection

Retrofit demonstrations of in-boiler sulfur control technology should be emphasized as a relatively low cost, near-term approach to reducing SO_2 emissions from existing boilers. The research projects conducted to date have shown that the process can reduce SO_2 emissions by 50% or more in utility applications at significantly lower capital cost than conventional flue gas desulfurization systems. The lower capacity factors and shorter remaining lives of older, currently uncontrolled plants typically favor a less capital intensive technology. The research to date has also provided engineers with the information needed to design successful injection systems and modify power plant operations to maintain the performance and reliability of the boiler and ancillary equipment despite the substantial increase of solids material in the flue gases. Current research is aimed at increasing the effectiveness of the process to improve its economic attractiveness and reduce the quantity of solid waste that needs to be disposed. Much of EPRI's current resources in the dry sorbent injection area are directed at developing the process for injection at moderate or low temperature (i.e., in the back part of the system rather than in the hot furnace). Not only could these processes work better than furnace injection, but their development will provide more options for utilities that best fit their site-specific requirements and constraints.

These research projects have laid the groundwork for prototype tests at a number of utility boilers in the 50-150 MWe size range. These prototype tests are an integral part of the development process and are necessary to provide confidence for commercial application. The issue here is the impact on performance and reliability of the boiler, particulate control device, and waste disposal system, not just the SO_2 removal efficiency.

Two prototype test programs are currently being planned or implemented. The Ohio Edison/Babcock & Wilcox/EPA project on a wall-fired boiler is in the detailed design phase, and EPRI has begun to participate by reviewing the injection system design as well as proposing complementary tests that might be funded b the Institute to round out the EPA program. EPRI and EPA are currently considering a cosponsored project to evaluate furnace sorbent injection on a tangentially-fired boiler with various sorbents, coals, injection systems, and particulate control device upgrades. We estimate that an additional four prototypes will be necessary to quantify the sorbent injection technology over the range of boiler types, sizes, coals, and injection processes that should be considered.

Unfortunately, the development of this technology is limited by the lack of funding necessary to implement these planned prototypes. Less than 40% of the approximately $85 million necessary to develop and demonstrate this technology over the next few years is budgeted by the Federal, state, and private sectors.

3. Gas Stream Cleanup

EPRI's hot gas filtration development efforts focus on gas filters for use in PFBC power plants. PFBC plants require the combustion gases to be cleaned of particulate before they enter the gas turbine to prevent erosion and fouling of gas turbine blades. EPRI shares the DOE's conviction that the most cost-effective way to clean PFBC gas is to do it at one location, ahead of the gas turbine, thus avoiding the need for a large, conventional post-gas turbine baghouse or electrostatic precipitator. EPRI's program began with analytical work and bench-scale testing in 1978. The early work identified porous ceramic filter media and electrostatic precipitators as the most promising candidates for the gas conditions of the PFBC turbocharged boiler (800°F, 10 atm). Success at the small scale has led to a new program to provide large-scale confirmation of the technology in the Grimethorpe PFBC pilot plant in England during 1986 and 1987. Two types of ceramic filters are to be tested there; woven ceramic bags and rigid porous filter cartridges.

As a quid pro quo for U.S. participation in the Grimethorpe filter test, the British Grimethorpe project sponsors will be providing the DOE and EPRI with access to all information resulting from the project. The minimum U.S. participation level required to gain access to this information is $10 million, split equally between EPRI and DOE. In order to be certain of the availability of this critical performance data to the U.S., both EPRI and DOE must commit to funding their respective portions of the new work to be done at Grimethorpe. For EPRI, this entails the design, installation and testing of the filter module described above. For DOE, this entails the design, installation and testing of a new coal water feed system.

The DOE has built and plans to test a large high pressure (10 atm), high temperature (1600°F) electrostatic precipitator (ESP) on the New York University (NYU) PFBC test unit in 1986. This ESP is unique in the world in that it is built with plate and wire electrode technology representative of full-scale, commercial ESP systems that would be used in PFBC power plants. It would be highly beneficial to U.S. utility companies and PFBC system developers to have this ESP tested at 10 atm and 800°F to simulate PFBC turbocharged boiler operating conditions.

This would verify theory regarding the ability to achieve high field strengths at the high gas densities existing in the first-generation PFBC turbocharged boilers. If such a joint DOE/EPRI test could be conducted in 1986, ESP technology would be available for PFBC turbocharged boiler power plants several years earlier than current development plans allow.

In conjunction with three leading potential PFBC equipment vendors, DOE plans to test three candidate gas filters in the NYU PFBC in 1986 (a ceramic cross flow filter, a granular bed filter and an electrostatic precipitator). The existing funding for this test will allow the accumulation of 250 hours total operation time on each gas filter. In EPRI's experience, this is inadequate time to thoroughly qualify new systems and conduct meaningful tests. This is especially true for the ESP because the performance of this type of filter normally degrades with time (and may not become steady for up to 2000 hours) as the discharge and collecting electrodes become fouled with ash deposits. In order to assure the collection of quality data, the DOE should be prepared to increase the scope of these filter tests to allow the operation of each device for the minimum time required to gain confidence in the component operability, to reach steady state operating conditions and to gather valid performance data for commercial plant design.

DOE should commit to the design, manufacture, installation and testing of an alternative gas filter in the EPRI Grimethorpe filter vessel after the conclusion of the EPRI test program. For comparatively small incremental funding, DOE would be able to scale-up and test the best NYU device by a factor of ten. Such a filter test could be accomplished in late 1987.

Extrapolation of the test and design data arising from the Grimethorpe filter test to commercial scale filters is a critical need presently not being filled either by DOE or EPRI. A new program to perform engineering and conceptual design of commercial filters should be undertaken using the performance results from the Grimethorpe filter tests. These new filter designs would be incorporated into exsiting conceptual plant designs and the effect on plant capital cost and efficiency evaluated.

4. Waste Management

Little attention has been given to date to secondary pollution questions associated with air pollution control, notably compliance with Clean Water Act/NPDES and RCRA. In addition to a very large increase in both solid and liquid waste products created by retrofit control requirements, these requirements will produce by-products of different characteristics--e.g., more soluble sodium and calcium in waste solids from furnace limestone injection than conventional wet limestone scrubbing.

The FY1987 DOE budget request in the waste management area is limited to the completion of several on-going efforts primarily in the sampling and characterization of organic and inorganic species in wastes produced by the "emerging" technologies, and studies of the energy potential from coal preparation wastes.

During 1985 EPRI initiated a major project in management of solid waste materials from the new SO_2 control technologies. This project focuses on the by-products from spray drying, atmospheric fluidized bed combustion, limestone furnace addition, dry sodium addition and advanced physical coal cleaning. Within the 3 year project are activities dealing with information surveys and assessments, waste characterization, leachate testing, conceptual designs, case studies, and utilization options. This project provides an opportunity to coordinate the two programs.

Another opportunity for cooperative efforts is in the waste utilization area. We strongly encourage the continued funding of the Ash Utilization Design Engineering Textbook, as a mechanism for technology transfer to the engineers of tomorrow. The EPRI staff will work closely with the DOE Project Officer to provide input in this effort. This textbook project marks the return of the DOE into the waste utilization area after an absence of several years.

EPRI also recommends that DOE remain active in developing waste utilization alternatives. Private sector efforts are moving toward establishing a solid basis for choosing ash as an alternative raw material for road bases, landfill, structural aggregate, and cement substitutes. This may require several large demonstrations to develop generic (rather than site-specific) information. The using industries (highway/building constructors, etc.) are fragmented. No easily identified commercial entity exists to fund such work, but the cost savings and resource conservation value to the nation could be substantial.

Similarly, resources from ash (particularly aluminum, iron, gallium, and vanadium) have the potential to meet a large portion of national needs which are currently met by imports. Many of the benefits (balance of payments, freedom from foreign sources, national security, price stability) are difficult for private commercial funding sources to quantify and show an economic return. Federal support of such objectives is appropriate and essential.

EPRI has been funding the development of the direct acid leaching (DAL) process to recover metals from fly ash since 1979. The next step in the commercialization of this technology will be the construction of a 1500 lb/hour pilot plant that will cost $8 million to build and $1-5 million to operate. We would encourage both federal and private industry support to bring this technology closer to commercial success.

B. Advanced Research and Technology Development

1. Materials and Components

a. Materials

EPRI's projects in materials behavior in coal-based energy systems cover the following areas:

1) The lifetime of components in existing pulverized coal boilers: prediction of available life and methods of life extension. In general, these lifetimes are creep-limited.

2) Materials for heat-exchangers (gas coolers) in gasification combined cycle (GCC) plants. This has two thrusts: (a) determining the maximum acceptable temperature of existing materials (including surface treatments) and (b) developing materials coatings to allow this temperature to be increased. It has been shown that "downtime corrosion" due to the condensation of moisture on the cool tubes is a matter of considerable importance.

3) Coatings for gas turbine heat components. Industrial and utility gas turbines may suffer accelerated attack due to the presence of impurities in the fuel or the air. Improved coatings offer a method to combat this.

4) Erosion and erosion-corrosion of gas turbine components with reference to PFBC expander turbines. This work aims to define the lifetime of components as a function of the particle loading in the gas stream, to determine the minimum performance demanded of the hot gas clean-up system. The synergistic role of the presence of alkali salts in the gas stream has also been studied. The effect of this is to limit the maximum bed temperature that can be tested. This last factor is important principally for combined cycle PFBC. The turbo-expander in a turbocharged PFBC should be below the temperature range in which alkali induced corrosion is important.

5) Corrosion of in-bed components in fluidized bed combustors. This work has continued for several years, showing that sulfidation-oxidation corrosion is possible in the bed, even at nominally high excess air levels. Criteria to limit the attack in steam-raising FBC units have been developed. Advanced steam conditions and high temperature air heater systems present greater problems.

6) Erosion of in-bed components in fluidized bed combustors. This is the most important problem for both AFBC and PFBC. Studies are designed to identify improved design and operating procedures to minimize the metal loss. Additional work is aimed at determining the mechanism of the in-bed erosion process.

7) Development of refractory systems for slagging gasifiers.

There should be significant Federal involvement in those areas where the systems being investigated by the Federal government differ significantly from those being studied by EPRI. Thus, air-heater FBCs are of no great interest to EPRI at the moment, and thus our corrosion work is winding down. There should be more Federal effort. Erosion may well be a greater problem in smaller industrial AFBC boilers, in part because of the generally lower temperatures; these are not being studied in any detail by EPRI.

There have been joint materials programs at Grimethorpe. Work at national laboratories has also been jointly funded in some cases.

Industry-DOE interaction should be of significant benefit to both. DOE can orient the efforts of industry, and engage in technology transfer from one activity to another: this is often difficult for industry alone. The national laboratories are an important reservoir of talent able to conduct research on the more fundamental aspects of materials behavior in those severe environments.

b. Components

EPRI research into components, is limited to major components such as induced draft fans, feed water pumps, and pulverizers. A major area of interest is the wear of these components, and the activities of DOE in the mechanisms of discrete particle flow and in the stability of coal-water mixtures are clearly of importance.

C. Combustion Systems

1. Atmospheric Fluidized Bed Combustion

Development of Atmospheric Fluidized Bed Combustion (AFBC) has proceeded quickly during the past ten years from the small process confirmation size (e.g. EPRI/B&W 6' x 6' Development Facility) to the engineering prototype (TVA/EPRI 20 MWe Pilot Plant), and now to three 100-200 MW utility demonstration projects at TVA, Northern States Power and Colorado-Ute. Widespread commercial use of AFBC technology is also now evident at the industrial scale, with many new industrial cogeneration and utility retrofit projects in the design and construction stage. The capabilities of AFBC which have sparked this interest include (a) less sensitivity to fuel quality, enabling low grade/waste fuels to be burned, (b) ability to control SO_2 and NO_x within the combustion process and, (c) capability to be designed in multiple sizes and configurations with minimal cost sensitivity.

In each AFBC demonstration the utility industry is funding the largest portion, with EPRI and the suppliers sharing the first-of-a-kind costs. DOE's $30 million for the TVA/Duke Power/State of Kentucky demonstration is an important contribution to the financial closure of that project. Federal appropriations were also used to pay for nearly half of the $68 million TVA/EPRI 20 MWe AFBC Pilot Plant. In addition, DOE's industrial FBC demonstration programs at Georgetown and Great Lakes during the late 1970's and a mine-waste burning FBC in Shamokin, Pennsylvania, have helped further establish the technical confidence level.

In addition to sharing in the first-of-a-kind costs for the utility FBC demonstrations, the utility industry, equipment suppliers, and EPRI are jointly participating in:

- Test programs at each utility demonstration.
- Further design enhancements at the 20 MWe AFBC prototype.
- Coal and sorbent characterization and testing in order to establish a FBC design data base for all types of coal.

In these programs, coal companies and utility companies are supplying coal, sorbents, and testing personnel while EPRI, TVA and equipment suppliers are sharing in the costs of the test programs.

Though AFBC is proceeding into commercial application, considerable opportunity for continued DOE support exists. This support should be geared toward circulating fluidized bed demonstration test programs at both industrial and at a utility scale, FBC solid by-product utilization, and characterization of additional non-coal fuels. The former activity is needed to establish the engineering basis for large utility circulating bed boiler designs. Operating industrial scale units are inadequately instrumented to render the key scale-up data needed. The latter two are appropriate for DOE to support due to crossing institutional boundaries necessary for a cooperative effort. Examples are use of municipal/industrial waste as a fuel for power generation and private industry use of utility by-products. Developing a technology base in these areas is essential before such industrial/municipal/ utility coordination could be implemented. However, there is insufficient incentive to invest in this area of national energy interest at this time.

2. Pressurized Fluidized Bed Combustion

External and internal forces of change are causing utility companies to adopt altered generation expansion and retirement strategies. There is a strong trend toward smaller new-unit size plus utility priority on uprating the capacity of exist lowest possible cost. The advantages of small size and rapid construction are manifested by better matching of load growth and reduced construction work in progress. Measured in terms of equivalent capital cost, these benefits are equivalent to a reduction of 20% to 30%. Pressurized fluidized bed combustion (PFBC) offers the opportunity to add these advantages to the inherent advantages of AFBC, namely fuel flexibility and simple environmental control.

In order to rapidly commercialize PFBC technology with minimum technical risk, EPRI is dedicated to developing the PFBC turbocharged boiler. This PFBC technology, although not as efficient as second-generation combined cycle plants, also offers the advantages of shop fabrication, barge transportability and rapid field erection so that units of 150 to 250 MWe can be quickly added to a system. The system is applicable either as a new unit or as a retrofit; as a retrofit, it can either replace existing oil- or gas-fired boilers in their entirety or it can uprate existing units by supplementing steam-supply-limited boilers. In the PFBC turbocharged boiler, convection banks reduce the gas temperature to 800°F before it leaves the boiler. This lower temperature allows the use of near-conventional gas filters to remove particulates from the gas, minimizes turbine blade erosion and eliminates the need for expensive, high-temperature, refractory-lined gas pipes, waste heat boilers and large, conventional filters after the gas turbine.

Although the PFBC turbocharged boiler has less risk than the PFBC combined cycle at today's state of development, considerable effort is still required in both types before these systems can be widely adopted by the utility industry. Continued operation of two key pilot plants in England and Sweden have shown that the key technical uncertainties in PFBC are the design of in-bed tube bundles, the transfer of solids streams across a high pressure boundary and the overall control of an integrated PFBC/gas filter/gas turbine system.

The two large-scale facilities presently available for resolving these problems are located at Grimethorpe, England and Malmo, Sweden. The Grimethorpe facility was originally operated jointly for the government of the U.S., U.K. and W. Germany by the International Energy Agency (IEA). In 1985 the unit became private when its ownership and control were transferred to the British National Coal Board and the Central Electricity Generating Board and it was rechristened the Grimethorpe PFBC Establishment (GPFBCE). The Swedish plant is privately funded and operated by ASEA-PFBC, a unit of Stal Laval and ASEA.

Additional U.S. participation is being arranged for by a U.S. boiler vendor; either Babcock & Wilcox or Foster Wheeler will provide a new in-bed tube bundle of their own design for performance and reliability testing by the GPFBCE. A 500 hour test period in 1987 will use U.S. coal and dolomite and will provide data for commercial PFBC unit design in the U.S.

Conceptual designs and cost estimates of commercial plants have been created by various potential vendors of boilers, gas filters and gas turbines in conjunction with engineering firms using the results of the Grimethorpe experience. The results of each study indicates that PFBC is among the lowest cost clean coal alternatives for the production of electricity, particularly through repowering existing power plants.

The ultimate goal of the pilot plant operation and commercial design work is the demonstration of a full scale (ca. 100 MWe) PFBC turbocharged boiler on a utility system. Since mid-1985, Wisconsin Electric Power Company (WEPCO) has been evaluating the conversion of their 83 MWe Port Washington #5 unit to PFBC turbocharged boiler operation. This project embodies all of the aspects of the technology as identified by Brown Boveri, Foster Wheeler, and Research Cottrell for EPRI in a 1983-1984 study. As defined by WEPCo and the other team members, this project will cost about $90 million. A joint public/private initiative under the DOE Clean Coal Technology program with WEPCO, EPRI and the other team members is required to bring the project to reality. This project will provide full commercial scale demonstration of the technology and provide the design data base needed for broad commercial use in the 1990s.

3. Alternative Fuels

Coal-water slurries have been developed in recent years as a means of increasing the efficient use of coal. The two main types of coal slurries are those developed for long distance transportation and slurries which can be fired directly as a replacement for oil in oil design power plants. Both types of coal slurries have developed to the point of commercial readiness.

Transportation slurry is well developed and is used at Salt River Project, Nevada Power Company, Los Angeles Department of Water and Power, and Southern California Edison's Mohave station where slurry with about 50% coal and 50% water is transported by pipeline for several hundred miles from the mine to the power station. After partial dewatering, the coal is pulverized and fired.

Direct combustion coal-water slurry fuel (CWSF) contains about 70 wt.% coal, 20 wt.% water and 1 wt.% additives and can be fired directly almost as if it were heavy fuel oil. The development of CWSF has progressed rapidly and the technology appears ready for widespread commercial use. CWSF was developed primarily to reduce U.S. dependence on foreign oil and reduce fuel cost through displacement of oil with lower cost coal. The pace of commercial growth of CWSF has, however, been disappointing. This is a consequence of both perceived changes in oil availability, oil consumption reduction, and by dropping oil prices. As a result, the current price differential in favor of CWSF is not large enough to motivate potential users to switch. In addition, the perceived risk of changing from an "old" to a "new" fuel and the uncertainty of future energy scenarios make it difficult for processors who must scale up production from existing pilot plants to production plants to raise venture capital and the resulting chicken-and-egg problem between slurry processor and slurry user continues to hinder market growth.

To demonstrate the full potential of CWSF as an oil replacement and reduce the risks associated with conversion of oil design power plants to CWSF, a utility scale demonstration is required. Such a demonstration would allow integration of R&D completed to date by both DOE and EPRI in such areas as slurry characterization, development of utilization guidelines, and testing of slurry handling, pumping and firing equipment. From a regulatory standpoint, it is essential that boilers converting to CWSF be permitted to meet their existing emission requirements and not be forced to meet New Source Performance Standards (NSPS). Otherwise, commercial acceptance will be minimal.

4. Combustion Technology

Areas requiring additional effort include:

- Characterization of coal ash chemistry and its effect on combustion.
- Standardization of slagging indices.
- Effect of coal particle size on fouling/slagging.
- Effect of coal variability on power plant performance.
- Combustion diagnostics and effect on power performance.

Achievement of these objectives, which may be further accentuated if coal cleaning and switching are increased to meet emission control requirements, will first require expanded combustion testing facilities. These should include a 100 million Btu/h facility whose results could be directly extrapolated to commercial scale furnaces and boilers. It is also essential that smaller facilities be instrumented to measure the transient chemical and physical parameters throughout the combustion process as well as the properties of the resulting gaseous and particulate products. This capability could, for example, apply state-of-the-art measurement techniques developed with DOE support at the Sandia Combustion Facility. It might be most effectively implemented in conjunction with a stable university research program to achieve much needed national centers of excellence in coal science.

D. Fuel Cells

1. Fuel Cell-Gasification

Fuel cells are modular, environmentally acceptable power plants that offer the most efficient use of petroleum and natural gas in the near-term and coal-derived fuels in the longer-term.

Phosphoric acid fuel cells are expected to achieve commercial status by 1990. A market potential of 45,000 MWe is projected for the year 2000 with savings approaching 90 x 10^6 barrels of oil (equivalent) per year. The importance of this technology to the electric utility industry is described in separate testimony provided by the Fuel Cell Users Group of the Electric Utility Industry. Further evidence of the importance of phosphoric acid fuel cells to the electric utilities is provided by the increased commitments of five Japanese and two U.S. manufacturers to large scale demonstration and commercial prototype projects.

However, the commercial success of phosphoric acid fuel cells is not assured and will depend upon continued technology improvements to achieve the reliability and the capital costs necessary to penetrate the market and achieve the projected benefits. The absence of any funding for phosphoric acid fuel cells in the Department's FY87 budget ignores the needs of ongoing programs as well as the progress being made under the coordinated support of DOE and EPRI. These efforts if sustained at current levels promise to achieve the cost targets while improving the power plant efficiency from the current 40% to as much as 47%. Beyond this, the integration of fuel cells with coal gasifiers needs to be explored to confirm the projected coal to AC power efficiency of 40% or more. EPRI will continue to support the development and commercial introduction of phosphoric acid fuel cell power plants during the 19861990 time period.

EPRI also supports the longer-range molten carbonate and solid oxide fuel cell technologies. We feel that the Department's FY87 request for these technologies is inadequate. The approximately 60% reduction from current levels is inconsistent with the longer term higher risk nature of these technologies.

E. Magnetohydrodynamics

EPRI continues to strongly recommend a continuing DOE open cycle magetrohydrodynamics (OCMEHD) program to support the activities at the Component Development and Integration Facility (CDIF) in Montana, the University of Tennessee Space Institute, and the necessary subsystem development programs to provide hardware for testing at these facilities. A federal investment of $35-40 million annually for at least the next 3-5 years is warranted. Such a program should focus on expanding an existing facility such as the CDIF into a fully integrated system test to assess the potential of OCMHD technology. Without such an integrated systems test, the technical readiness of the technology will remain uncertain. Depending on the success of this integrated systems test, it may be appropriate to develop a new larger scale facility.

EPRI has had a modest R&D program in OCMHD, concentrating on the development of the MHD channel-inverter interface and the power conditioning of the inverter output to be compatible with electric utility system requirements. In addition, we have supported numerous design studies to estimate the performance and costs of potential commercial systems. Although we presently do not see a large economic "carrot" for this technology without further development, high efficiency systems for utilizing coal in an environmentally acceptable manner clearly are in the national interest and are consistent with DOE R&D objectives and priorities.

Finally, EPRI has been considering an MHD approach wherein coal is first gasified, as discussed earlier, cleaned of its particulate and sulfur, and then fired either with oxygen or air prior to entering the MHD channel. This approach is similar to that being taken in the Soviet Union, however, we would be combusting syngas from coal rather than natural gas. In this way, we could eliminate chemical regeneration requirements of the seed material and eliminate potential slag in the channel and downstream equipments. This concept may offer an interesting option to the conventional coal-fired MHD approach.

In summary, we believe that integrated test facility data should be obtained and design studies conducted before a new facility commitment is made. If this were to become a key objective of the DOE and EPRI activities, such definition should be forthcoming within the next 2-3 years. With other advanced coal technologies emerging, it would appear that this would be a reasonable time frame for such a decision.

F. Coal Liquefaction

1. Once Through Methanol

For many years, EPRI has supported work on the Once Through Methanol (OTM) concept as part of its program to develop the Integrated Gasifier Combined cycle (IGCC) as a means of producing clean coal derived power. OTM refers to the coproduction of methanol and electricity in IGCC plants by partial conversion of the synthesis gas. Studies have shown that OTM produces methanol at a lower cost than other synthetic liquids due to the use of incremental gasifier capacity, avoidance of water gas shift, and the elimination of gas recycle which would ordinarily be required for methanol synthesis. OTM requires a methanol reactor which can convert the carbon monoxide rich gas produced in coal gasification.

A demonstration of this technology is now being planned that will use the existing TVA Muscle Shoals Texaco Gasifier. The methanol conversion technology selected is based upon the Liquid Phase Methanol (LPMeOH) reactor. The design is based on the successful 40 day run completed last year at Air Products' LaPorte PDU under the DOE funded project. EPRI has sponsored extensive planning and engineering studies in addition to gas cleanup testing at the TVA site. The overall project, including design, construction and a year of operation will cost about $40 million. EPRI understands that half of the funding will be requested in a proposal by Air Products and TVA to the Clean Coal Solicitation with the balance provided by EPRI, TVA, and other interested parties.

Mr. FUQUA. Thank you very much, Dr. Mannella.

We will now hear from Dr. Mechlin.

Dr. MECHLIN. Mr. Chairman, ladies and gentlemen, my name is George Mechlin. I am vice president for research and development of the Westinghouse Electric Corp. It is a great privilege to be allowed to speak before you today. Those of us who work for Westinghouse are the heirs of a hundred years of energy research and development. We are a company which maintains a close touch worldwide with electric utilities, equipment manufacturers and the consumers of electricity.

Our founder, George Westinghouse, introduced alternating current as the now standard and universal basis for electricity utilization. In this tradition, Westinghouse is participating in a broad spectrum of national energy development efforts. This includes fuel cells, advanced combustion turbines, surface coal gasification and gas cleanup, and magnetohydrodynamics. We are also involved in atmospheric fluidized bed air heaters, combustion systems studies for advanced pressurized fluidized bed combined cycle systems, and conservation efforts such as photovoltaics and wind turbines.

Each of these technology developments involve established partnerships where there is a strong intent and commitment for commercialization. In many cases the private sector has, is and will provide more than half of the economic resources necessary to complete the developments. These are ongoing and continuing programs that need continuity and commitment from all the partners if they are to achieve success.

I will discuss with you today just one of these technologies as an example for the continuing need for Government support. Fuel cells are a much needed and very promising element of our future means of generating electricity from fossil fuels in a safe, efficient and environmentally benign fashion.

I need not apprise this committee of the promise, virtues or benefits of fuel cells. I know you have heard this story many times, but there is a need for continued national support. That need arises from the fact that, while the basic technology is well understood, there are important technical refinements in materials and designs yet to be achieved. Testing necessary to achieve the accepted status of a proven technology requires substantial future research and development.

Two elements of risk can be identified in any energy project. The first risk is the ability of the technology to perform the hoped-for function. The second is the acceptance of the public at large that the new capability is needed and produces benefits sufficient to justify market prices which must be paid. The supersonic transport aircraft is an excellent example. No one can doubt that the SST can fly at supersonic speed. It seems equally certain for the great majority of travelers the time saved is worth much less than the premium costs. The market is obviously much, much smaller than the project sponsors had hoped for.

The business community has come to regard energy research as a very risky and unpredictable undertaking. There are continuing wide swings in prices and availabilities occurring over time spans comparable to the incubation time of the technological projects which produce new energy sources or more efficient devices.

One need look only at what is said by some to be a dangerous overextension of credit by our banking institutions, to certain oil producing developing countries to obtain a measure of the deep concern of the money managers of the United States toward investment in energy projects.

The research and development efforts on the several types of fuel cells have progressed to the point where an evolution of technology can confidently be predicted in much the same manner as the evolution of aviation which produced successively higher performance capabilities and larger aircraft as aluminum replaced varnished canvas and turbo-jets replaced piston engines. Fuel cells based on phosphoric acid as an electrolyte represent a near-at-hand generation of technology with impressive advantages in efficiency and environmental quality. A later generation just emerging from the research phase based on the electrical conducting properties of certain metal oxides at elevated temperatures offers increased efficiency, fuel versatility and application flexibility in the future.

The research and development efforts on both of these fuel cell systems are currently being supported by a substantial and broad-based funding from the private sector and by the Department of Energy. This support is threatened with extinction by short-sighted budget cutting motives of the executive branch. To expect that the private sector will alone accept the general risk inherent in energy projects is unrealistic. A more accurate view is that the withdrawal of Government research and development support will be interpreted by the private sector as a clear signal that the risk has risen to an unacceptable level and the private sector will withdraw also, leaving only the collapse of future hopes for the technology and its contribution to our society.

The case for continued national support of fuel cell research and development is very strong. It is based on a series of important considerations. In the early years of the next decade, there is a growing consensus that the electric utility companies in some regions of our country will be unable to install or obtain sufficient generation capacity to meet the needs of our homes and factories. This shortage will not be easy to rectify by conventional generation technology, meeting all the restraints imposed by the need to preserve the optimum use of land and water resources which would be required for generation sites, for transmission lines and waste disposal.

The preservation of air quality values and the amelioration of acid rain impose further burdens which conventional electricity generation technology finds increasingly difficult to meet. The finance and time constraints on power plant and transmission line construction are further obstacles to the timely amelioration of what will be a growing capacity shortage.

That this shortage of electricity will exacerbate the disadvantages in U.S. industrial competitiveness which is already a domestic employment problem and a major international trade problem for our country is a very alarming prospect. The compactness and environmental capability of the fuel cell makes it a very desirable option to have available to be put into utility systems where it is needed with short lead times and with excellent fuel efficiencies which lead to electricity costs acceptable to consumers.

The solid oxide version of the fuel cell is additionally very suitable for cogeneration because of the high quality of its reject heat so as to be a potential significant additional improvement to our U.S. industrial competitiveness.

The Government support of past years has made the United States the undisputed world leader in fuel cell technology today. The advantages in efficiency, in environmental quality, in flexibility of siting and short installation lead times make the fuel cell electricity generating systems as attractive in other countries as they are in the United States.

Japan is a particularly interested country. The Ministry of International Trade and Industry and the Agency of Industrial Science and Technology are systematically funding and encouraging Japanese industry to duplicate and acquire fuel cell technology equivalent to that where we now have technological superiority. If we maintain our lead through continuation of our national support of research and development, which I would judge to be about 5 years, we can maintain the Japanese, and all other countries as well, as customers for our equipment.

That this is possible is evidenced by the continued international lead of the U.S. aviation industry. Fuel cells for the generation of electricity are an opportunity for jobs and prosperity in the United States which the wise programs of the past have put in our hands. We need your support and action in continuing the research and development efforts which will bring this much-needed technology to fruition as an element of our mix of electricity generation options and an advantage in international trade.

As mentioned earlier, Westinghouse is involved in a number of alternative technologies, ongoing programs under the cognizance of this committee. The recently submitted DOE deferral request devastates these programs. The Government's share of funding for these programs has run out. It is our hope that the Congress will be able to take prompt and definitive action to overturn these deferrals.

My corporation appreciates the role that Congress and this committee have played in the past in providing some of the funding necessary to move these promising technologies toward commercialization. We strongly urge Congress to continue to provide the funds necessary to maintain these established government/private sector technology development partnerships so that taxpayer benefitting new energy efficient products can be brought into the marketplace.

Our people will work with your staff on the details of our fiscal year 1987 funding needs. We will provide you whatever data might be needed for you to make your authorization determinations for fiscal year 1987.

[The prepared statement of George Mechlin follows:]

STATEMENT OF DR. GEORGE F. MECHLIN, VICE PRESIDENT, RESEARCH AND DEVELOPMENT, WESTINGHOUSE ELECTRIC CORP. ON FUEL CELLS AND OTHER ALTERNATIVE ENERGY TECHNOLOGY DEVELOPMENTS

Good Morning Mr. Chairman, Ladies and Gentlemen: My name is George Mechlin. I am Vice President for Research and Development of the Westinghouse Electric Corporation. It is a great privilege to be allowed to speak before you today. Those of us who work for Westinghouse are the heirs of a hundred years of energy research and development. We are a company which maintains a close touch world-wide with electric utilities, equipment manufacturers and the consumers of electricity.

Our founder, George Westinghouse, introduced alternating current as the now standard and universal basis for electricity utilization. In this tradition, Westinghouse is participating in a broad spectrum of the national energy development efforts. This includes Fuel Cells, advanced combustion turbines (heat engines), surface coal gasification and gas cleanup, and magnetohydrodynamics (MHD). We are also involved in atmospheric fluidized bed air heaters, combustion systems studies for advanced pressurized fluidized bed combined cycle systems, and conservation efforts such as photovoltaics and wind turbines.

Each of these technology developments involve established partnerships where there is a strong intent and commitment for commercialization. In many cases the private sector has, is and will provide more than half of the economic resources necessary to complete these developments. These are on-going and continuing programs that need continuity and commitment from all the partners if they are to achieve success.

I will discuss with you today just one of these technologies as an example for the continuing need for governmental support. Fuel cells are a much needed and very promising element of our future means of generating electricity from fossil fuels in a safe, efficient and environmentally benign fashion.

I need not apprise this committee of the promise, virtues or benefits of fuel cells. I know you have heard this story many times but there is a need for continued national support. That need arises from the fact that while the basic technology is well understood, there are important technical refinements in materials and designs yet to be achieved. Testing necessary to achieve the accepted status of a proven technology requires substantial future research and development.

Two elements of risk can be identified in any energy projects. The first risk is the ability of the technology to perform the hoped for function. The second is the acceptance of the public at large that the new capability is needed and produces benefits sufficient to justify market prices which must be paid. The supersonic transport aircraft is an excellent example. No one can doubt that the SST can fly at supersonic speed. It seems equally certain for the great majority of travelers, the time saved is worth much less than the premium costs. The market is obviously much, much smaller than the project sponsors had hoped for.

The business community has come to regard energy research as a very risky and unpredictable undertaking. There are continuing wide swings in prices and availabilities occurring over time spans comparable to the incubation times of the technological projects which produce new energy sources or more efficient devices. One need look only at what is said by some to be a dangerous over-extension of credit by our banking institutions to certain oil producing, developing countries to obtain a measure of the deep concern of the money managers of the United States toward investment in energy projects.

The research and development efforts on the several types of fuel cells have progressed to the point where an evolution of technologies can be confidently predicted in much the manner as the evolution of aviation which produced successively higher performance capabilities and larger aircraft as aluminum replaced varnished canvas and turbo-jets replaced piston engines. Fuel cells based on phosphoric acid as an electrolyte represent a near-at-hand generation of technology with impressive advantages in efficiency and environmental quality. A later generation just emerging from the research phase based on the electrical conducting properties of certain metal oxides at elevated temperatures offers increased efficiency, fuel versatility and application flexibility in the future.

The research and development efforts on both of these fuel cell systems are currently being supported by substantial and broad based funding from the private sector and by the Department of Energy. This support is threatened with extinction by short sighted budget cutting motives of the executive branch. To expect the private sector will alone accept the general risks inherent in energy projects is unrealistic. A more accurate view is that the withdrawal of government research and development support will be interpreted by the private sector as a clear signal the risk has risen to an unacceptable level and the private sector will withdraw also leaving only the collapse of future hopes for the technology and its contribution to our society.

The case for continued national support of fuel cell research and development is very strong. It is based on a series of important considerations. In the early years of the next decade, there is a growing consensus that the electric utility companies in some regions of our country will be unable to install or obtain sufficient generation capacity to meet the needs of our homes and factories. This shortage will not be easy to rectify by conventional generation technology, meeting all the restraints imposed by the need to preserve the optimum use of land and water resources which would be required for generation sites, for transmission lines and waste disposal. The preservation of air quality values and the amelioration of acid rain impose further burdens which conventional electricity generation technology finds increasingly difficult to meet. The finance and time constraints which exist on power plant and transmission line construction are further obstacles to the timely amelioration of what will be a growing capacity shortage. That this shortage of electricity will exacerbate the disadvantages in U.S. industrial competitiveness which is already a domestic employment problem and a major international trade problem for our country is a very alarming prospect. The compactness and environmental compatibility of the fuel cell makes it a very desirable option to have available to be put into utility systems where it is needed with short lead times and with excellent fuel efficiencies which lead to electricity costs acceptable to consumers. The solid oxide version of the fuel cell is additionally very suitable for cogeneration because of the high quality of its reject heat so as to be a potential significant additional improvement to our U.S. industrial competitiveness.

The Government support of past years has made the United States the undisputed world leader in fuel cell technology today. The advantages in efficiency, in environmental quality, in flexibility of siting and short installation lead times make fuel cell electricity generating systems as attractive in other countries as they are in the United States. Japan is a particularly interested country. The Ministry of International Trade and Industry and the Agency of Industrial Science and Technology are systematically funding and encouraging Japanese industry to duplicate and acquire fuel cell technology equivalent to that where we now have technological superiority. If we maintain our lead through continuation of our national support of research and development which I would judge to be about five years, we can maintain the Japanese (and all other countries as well) as customers for our equipment. That this is possible is evidenced by the continued international lead of the United States aviation industry. Fuel cells for the generation of electricity are an opportunity for jobs and prosperity in the United States which the wise programs of the past have put in our hands. We need your support and action in continuing the research and development efforts which will bring this much needed technology to fruition as an element of our mix of electricity generation options and an advantage in international trade.

As mentioned earlier, Westinghouse is involved in a number of alternative technologies; ongoing programs under the cognizance of this committee. The recently submitted DOE Deferral Request devastates these programs. The government's share of funding for these programs has run out. It is our hope that the Congress will be able to take prompt and definitive action to overturn these deferrals.

My corporation appreciates the role that Congress and this Committee has played in the past providing some of the funding necessary to move these promising technologies towards commercialization. We strongly urge Congress to continue to provide the funds necessary to maintain these established Government Private Sector technology development partnerships so that taxpayer benefitting new energy efficient products can be brought into the marketplace.

Our people will work with your staff on the details of our fiscal 1987 funding needs. We will provide you with whatever data might be needed for you to make your authorization determinations for FY 1987. Thank you.

Council on Synthetic Fuels

Statement

by

Michael S. Koleda
President
Council on Synthetic Fuels

with respect to

Fiscal 1987 Budget Authorization Request
Department of Energy Fossil Energy Programs

Before the

U.S. House of Representatives
Committee on Science and Technology
Subcommittee on Energy Development and Applications

Room 2318
Rayburn House Office Building
Washington, D.C.

March 4, 1986

1501 Pennsylvania Avenue, N.W. • Suite 325 • Washington, D.C. 20004 • (202) 347-7069

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE my name is Michael S. Koleda. I am president of the Council on Synthetic Fuels, a trade association of companies with a long-term business interest in synthetic and advanced fossil fuel technologies.

You have invited my comment on the DOE FY 1987 request for fossil R&D programs.

I would like to focus my attention today on the synthetic fuels portion of the fossil R&D budget, because that is the area the Council has followed with the most interest over the years. I believe, however, my comments will apply more broadly. At the moment, I am not in a position to speak to the specific program items before you. Instead, I will address the context in which I believe the DOE request must be considered and the challenge that we in industry share with you in Congress at this point in our energy history.

The Department of Energy has requested a FY 1987 synthetic fuels R&D funding of $18.3 million.

It is the smallest by far of the requests submitted by the Reagan Administration, representing slightly more than 10% of the FY 1982 Congressional funding in support of these programs. If Congress accepts the Administration request, we are talking about spending 11 cents in FY 1987 on synfuels R&D for every dollar spent in FY 1982, without correcting for the intervening effects of inflation.

Over the past five years, the Administration has requested from $43 to $48 million in annual synfuels R&D spending. Typically, Congress has chosen to roughly double the request with new budget authority ranging from $78 to $95 million. Down 62% from last year's level, the FY 1987 administration request sharply departs from this pattern.

Table 1

Synthetic Fuels R&D Spending
(millions of as-spent dollars)

	1983	1984	1985	1986	1987
Request	43	45	47	48	18
Final	95	88	78	92	??
Request as % Final	45%	51%	60%	53%	??

Table 2
Synthetic Fuels R&D as a Share
of Total Fossil R&D

	1983	1984	1985	1986	1987
Synfuels R&D	95	88	78	92	
Total Fossil	920	357	275	311	
Share	10%	25%	28%	29%	

Each Administration has its own philosophy and it is well known that the Reagan Administration favors minimal government involvement in the energy area. The Department that houses the programs we consider today was targetted for elimination when the Administration came to office. The first official act of the President upon assuming office was to complete the decontrol of oil prices begun by President Carter. The President likes to rely on markets and nowhere is this more true than in energy.

By and large, industry tends to agree with the Administration's energy positions. Certainly, prices are an efficient means of allocating energy supplies, and act as signals to producers and consumers alike. The price controls of the 1970s led to over consumption and under production of energy. But this is not to argue that there is no role for government in the energy arena. However, the justification for government spending in energy as in other areas must rest on a belief that the market will undervalue certain areas given their importance to the nation as a whole.

In the synthetic fuels industry, many believe that one such area is the demonstration of available synthetic fuel technologies at comercial scale. These people believe that the most progress will be made in demonstrating at comercial scale what we already know to work in the laboratory and at pilot plant scale. Others, perhaps recognizing the futility of such an approach in the current climate, look to practical research and development projects to lead to improved technologies -- the so-called next generation -- to be available for demonstration when the time is more propitious.

It seems to me the Administation has placed a challenge before this committee with the FY 1987 request for fossil fuel R&D spending. The challenge is whether a justification exists at all for government support to synfuels R&D spending. The annual requests, after all, would appear to be approaching zero.

With the passage of Gramm-Rudman-Hollings the Administration has been forced to make choices no less so than will the Congress. The Administrations budget may be DOA, but the defense budget without relenting to a tax increase, the President has chosen to make the numbers work by sharp cuts in programs such as those under the jurisdiction of this committee.

Against the background of falling oil prices since the Administration came to office and a precipitous decline in the past few weeks, ...against the background of ample energy supplies, declining prices at the pump, and diversification of U.S. oil imports from the Persian Gulf nations to greater reliance on imports from Canada and Mexico,...against the background of substantial conservation that is likely to continue in the years ahead, ...and against the background of our collective experience with the U.S. Synthetic Fuels Corporation, ...I nonetheless remain convinced that we abandon a responsible government presence in long range energy options development, such as synthetic fuels technologies, at our great peril.

The market tends, after all, to be driven by short-term considerations. The timetable for the development of new synthetic and alternate fossil fuel technologies is measured in years. The decisions of the major energy companies in this climate of falling oil prices are quarter-to-quarter. They have to do less with preparations for tomorrow than with survival today. The comforting belief that the market will make the necessary investments comes apart if "necessary" is meant to include investments that are prudent for a government but imprudent for a private company.

Within a decade we have seen oil prices surge to unheard of heights only to fall to the relative depths of today. Was this an aberration? Or are we experiencing the effects on world oil markets of the policy decisions of Saudi Arabia on the level of production that it deems in its own long-term interest? Are we headed toward a sharply higher reliance on Middle East oil? Are we embarked on a "march of folly" as we abandon alternate energy options development and increase our imports from a region of the world we know from recent experience to be among the most politically unstable? Is the marketplace to answer these questions? Are these no longer legitimate questions of Congressional discourse and action?

There appear to be two schools of thought on the future path of oil prices within industry circles. One group sees soft oil markets well into the future, for perhaps a decade or more. Another group believes Saudi Arabia will begin to curtail production once it has supplanted the production of the higher cost producers, which could occur within a much shorter time period.

In the meantime, low oil prices strain corporate cash flows. Investments that don't yield near term results are harder to justify. The investment horizon comes closer. The long term approach is harder to sell.

Mr. Chairman, that is the climate in industry, and I suspect it is the situation you in the Congress face as well.

In industry we accept the realities of the moment. Despite the energy facts that other witnesses have presented to you this morning, the public does not believe there is an energy problem. The Administration position seems to be that any problem that might exist is best left to the market to resolve. For a number of reasons, synthetic fuels projects have gotten a bad name over the course of the past few years. The technical successes that we have had are not widely enough appreciated. We recognize the long lead time required to develop alternate energy options to have available when the inevitable oil squeeze returns. And we accept that the private sector will not step forward in the current business climate to continue the development effort.

Under these conditions, the Council now turns its attention to an assessment of the technological lessons since the oil price run-ups of the 1970s. We feel a responsiblity to provide the government with our advice on how best to proceed and in what directions when, inevitably, the extent of our vulnerability to energy politics once again becomes apparent to the public and our elected leaders.

Mr. Chairman, I applaud you and the members of your committee for holding these hearings and for your efforts to assure that we don't mistake the current period of falling energy prices for long term stability. We look forward to being of assistance to you, the Committee, and the Administration in your efforts to identify promising areas of research support.

Mr. **Fuqua**. Thank you very much.

Michael Koleda, we will be glad to hear from you at this time.

Mr. **Koleda**. Thank you, Mr. Chairman.

My name is Michael Koleda. I am president of an organization called the Council on Synthetic Fuels, a trade association of companies with a long-term business interest in synthetic fuels and advanced fossil fuel technologies.

I might say that a founder of our organization and principal mover behind it, a close friend of yours, Mr. Fuqua, Walter Flowers, was instrumental in the activities of this committee. I thought a little bit about what Walter might have advised that I say in this testimony. I have no way of knowing whether I've got it right, but I am going to make a stab at it.

I don't have some specific answers for you. I would like to be able to tell you what the industry thinks you ought to spend the funds that you do have on this year. But for a variety of reasons, that kind of an answer doesn't readily come out of a trade association.

But I do want to take the opportunity to share with you some of the rumblings or feelings that I gather from talking to individuals in the synthetic fuels industry these days. The Department of Energy has requested a fiscal year 1987 funding level in R&D in synfuels of about $18 million. We have heard the phrase decimation used here today. This is by far the smallest of the requests submitted by the administration. It represents slightly more than 10 percent of the 1982 funding support for these programs, fiscal year 1982. So, I suppose decimation isn't too far off the mark over that period of time.

Over the past 5 years the administration has requested roughly $43 to $48 million in annual funding for synfuels R&D. Typically, Congress has chosen to roughly double that figure. We are down 62 percent, however, in the request from last year's level. So, it is a significant departure on the part of the administration of this year over last. And I am not talking here about the further impact of the deferrals that have been referred to in testimony.

Every administration has its philosophy. That is certainly appropriate. It is well known that the current administration favors a minimal Government involvement in the energy area. The department that houses the programs we are considering here today was targeted for elimination by the administration, as you know. The President's first official energy act, in fact his first official act, as I recall, upon taking office was to complete decontrol of oil prices that his predecessor had begun. The President likes to rely on markets wherever he can, and I suspect that nowhere is that more true than in the energy area.

By and large, industry tends to agree with this approach. Certainly it is industry's view that prices are an efficient means of allocating energy supplies. They do act as signals to producers and to consumers. The price controls of the seventies did lead to overconsumption and underproduction of energy. But this is not to argue that there is no role for government in the energy arena. It does, however, suggest that the justification for Government spending, as in other areas, certainly in energy, must rest on a belief that the market somehow will undervalue certain areas given their importance to the Nation as a whole.

In the synthetic fuels area—I am talking here about technologies, for instance, like coal gasification combined cycle, which we include in that definition—many believe that one such area is demonstration. And I mention it here although I recognize that it is not the specific interest of the committee, but certainly many within industry believe that at the moment we do have a gap in demonstrating what we already know. Others, however, recognizing that we aren't going to make much progress in the current climate in that area, do look to practical research undertakings to develop what we are going to need to know for the next generation of technologies when that time is more propitious.

Clearly, as they have to industry, I believe the administration has placed a challenge before this committee which is undeniable. The spending requests are really terribly low compared to where they were 5 years ago. There is a question on the table about whether they are justified at all. With the passage of Gramm-Rudman, the administration has been forced to make choices, and it has made them. Basically, the message that comes through to us is that we are going to fund the defense budget without a tax increase, and here's how you do it. And how you do it is right on the table here today. You don't get anything like what you had.

Now, against the background of falling oil prices, since the adminstration came to office and dramatically in the last few weeks, given that, given the background of ample energy supplies, there is plenty around, and we have heard about it today, declining prices at the pump—maybe not as fast as the consumer would like—diversification of our reliance for oil imports away from the Persian

Gulf toward Canada, Mexico, Venezuela, the United Kingdom, against the background of substantial conservation that has taken place after the price runups of the 1970's, conservation that is likely to continue in the years ahead, and against the background, not a particularly pleasant one, of our experience with the United States Synthetic Fuels Corporation experiment of the last 5 years, nonetheless I and my colleagues in the synthetic fuels industry remain convinced that we abandon a responsible government presence in long-range energy options development at terrific peril.

The market, after all, tends to be driven by short-term considerations. The timetable for the development of the things we are talking about is measured in years. The decisions of the major energy companies in this falling oil price climate are quarter-to-quarter decisions. They have to do less with preparations for tomorrow than they do with survival today.

It is comforting to believe that the market takes care of these kinds of decisions, but that belief comes apart if necessary undertakings are meant to include investments that are prudent for government and imprudent for private companies. And that is precisely the kind of projects we are talking about in the synthetic fuels area. Their justification is not found in the private marketplace.

We have seen oil prices drop dramatically within a decade. It may have been an aberration; some think so. Are we experiencing the effects of world oil markets, the policies of Saudi Arabia on the level of production? That is quite likely, I suspect.

Are we headed toward a sharply higher reliance on Middle Eastern oil? Most people I talk to believe that is the inevitable direction.

Are we embarked on what Barbara Tuchman called in her book a march of folly, abandoning alternate energy options development, increasing our imports on a region that we have practical recent experience to know to be among the most politically unstable in the world? Is the marketplace supposed to deal with this? Aren't these legitimate questions for congressional discourse and action? I know the climate isn't good. There appear to be two schools of thought on the future path of oil prices from the people that I have been talking with in industry. One group sees soft oil markets well into the future, say, a decade or so, to pick a number. Another group believes Saudi Arabia will begin to curtail production once it has picked up the slack, that is, these stripper wells that are being shut down and other production, high cost production that is going to be shut down once they have gotten that share of the market back.

Perhaps the price increases that will result from tightening markets at that time will be quite a bit slower because certainly they would not be interested in triggering the kind of conservation or production that they did last time.

In the meantime, the low oil prices really do strain corporate cash flows. Investments that don't pay off fast are hard to justify. The investment horizon in industry is coming closer. The long-term approach is getting harder to sell. That is the climate we face in industry. And I think you've got the same problem here.

Now, what about the synthetic fuels industry in this climate? We accept the realities of the moment. Despite the energy facts that we have all heard here today, the public doesn't believe there is any kind of an energy problem. The administration seems to believe that any problem that might exist is best left to the market to resolve. For a number of reasons, synthetic fuels projects have gotten a bad name.

The technical successes that we have had are not widely appreciated. I am talking about the cool water project. I would also add that the Great Plains project, despite all the bad press, it produces high cost gas; but technologically it has been quite a success. There are some problems, odor problems. If there is an area that I would direct this group to, I think it is the question of cleaning up odor problems, environmental problems of that kind. That technology is not as far along as it ought to be.

We recognize the long lead time that is required to develop alternate energy options to have available when the squeeze returns. And we accept that the private sector will not step forward in the current business climate to continue that effort.

Now, so what do we do? As an industry group, I can assure you that we will now turn our attention to assessing what technological lessons we have learned since the oil embargo and problems of the 1970's. We feel an acute responsibility to be in a position that we are not now in today, I am sorry to say, to provide the Government with our advice on how best to proceed and in what directions, when inevitably the extent of our vulnerability to energy politics once again becomes apparent to the public and to our elected leaders.

I think you are doing a wonderful thing here in holding these hearings and in your efforts to ensure that we don't mistake this current period of falling energy prices for any long-term stability.

We look forward to assisting you and the administration and others in efforts to identify promising areas of research.

Thank you very much.

[The prepared statement of Michael Koleda follows:]

Council on Synthetic Fuels

Statement

by

Michael S. Koleda
President
Council on Synthetic Fuels

with respect to

Fiscal 1987 Budget Authorization Request
Department of Energy Fossil Energy Programs

Before the

U.S. House of Representatives
Committee on Science and Technology
Subcommittee on Energy Development and Applications

Room 2318
Rayburn House Office Building
Washington, D.C.

March 4, 1986

1301 Pennsylvania Avenue, N.W. • Suite 325 • Washington, D.C. 20004 • (202) 347-7069

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE my name is Michael S. Koleda. I am president of the Council on Synthetic Fuels, a trade association of companies with a long-term business interest in synthetic and advanced fossil fuel technologies.

You have invited my comment on the DOE FY 1987 request for fossil R&D programs.

I would like to focus my attention today on the synthetic fuels portion of the fossil R&D budget, because that is the area the Council has followed with the most interest over the years. I believe, however, my comments will apply more broadly. At the moment, I am not in a position to speak to the specific program items before you. Instead, I will address the context in which I believe the DOE request must be considered and the challenge that we in industry share with you in Congress at this point in our energy history.

The Department of Energy has requested a FY 1987 synthetic fuels R&D funding of $18.3 million.

It is the smallest by far of the requests submitted by the Reagan Administration, representing slightly more than 10% of the FY 1982 Congressional funding in support of these programs. If Congress accepts the Administration request, we are talking about spending 11 cents in FY 1987 on synfuels R&D for every dollar spent in FY 1982, without correcting for the intervening effects of inflation.

Over the past five years, the Administration has requested from $43 to $48 million in annual synfuels R&D spending. Typically, Congress has chosen to roughly double the request with new budget authority ranging from $78 to $95 million. Down 62% from last year's level, the FY 1987 administration request sharply departs from this pattern.

Table 1

Synthetic Fuels R&D Spending
(millions of as-spent dollars)

	1983	1984	1985	1986	1987
Request	43	45	47	48	18
Final	95	88	78	92	??
Request as % Final	45%	51%	60%	53%	??

Table 2
Synthetic Fuels R&D as a Share
of Total Fossil R&D

	1983	1984	1985	1986	1987
Synfuels R&D	95	88	78	92	
Total Fossil	920	357	275	311	
Share	10%	25%	28%	29%	

Each Administration has its own philosophy and it is well known that the Reagan Administration favors minimal government involvement in the energy area. The Department that houses the programs we consider today was targetted for elimination when the Administration came to office. The first official act of the President upon assuming office was to complete the decontrol of oil prices begun by President Carter. The President likes to rely on markets and nowhere is this more true than in energy.

By and large, industry tends to agree with the Administration's energy positions. Certainly, prices are an efficient means of allocating energy supplies, and act as signals to producers and consumers alike. The price controls of the 1970s led to over consumption and under production of energy. But this is not to argue that there is no role for government in the energy arena. However, the justification for government spending in energy as in other areas must rest on a belief that the market will undervalue certain areas given their importance to the nation as a whole.

In the synthetic fuels industry, many believe that one such area is the demonstration of available synthetic fuel technologies at comercial scale. These people believe that the most progress will be made in demonstrating at comercial scale what we already know to work in the laboratory and at pilot plant scale. Others, perhaps recognizing the futility of such an approach in the current climate, look to practical research and development projects to lead to improved technologies -- the so-called next generation -- to be available for demonstration when the time is more propitious.

It seems to me the Administation has placed a challenge before this committee with the FY 1987 request for fossil fuel R&D spending. The challenge is whether a justification exists at all for government support to synfuels R&D spending. The annual requests, after all, would appear to be approaching zero.

With the passage of Gramm-Rudman-Hollings the Administration has been forced to make choices no less so than will the Congress. The Administrations budget may be DOA, but the defense budget without relenting to a tax increase, the President has chosen to make the numbers work by sharp cuts in programs such as those under the jurisdiction of this committee.

Against the background of falling oil prices since the Administration came to office and a precipitous decline in the past few weeks, ...against the background of ample energy supplies, declining prices at the pump, and diversification of U.S. oil imports from the Persian Gulf nations to greater reliance on imports from Canada and Mexico,...against the background of substantial conservation that is likely to continue in the years ahead, ...and against the background of our collective experience with the U.S. Synthetic Fuels Corporation, ...I nonetheless remain convinced that we abandon a responsible government presence in long range energy options development, such as synthetic fuels technologies, at our great peril.

The market tends, after all, to be driven by short-term considerations. The timetable for the development of new synthetic and alternate fossil fuel technologies is measured in years. The decisions of the major energy companies in this climate of falling oil prices are quarter-to-quarter. They have to do less with preparations for tomorrow than with survival today. The comforting belief that the market will make the necessary investments comes apart if "necessary" is meant to include investments that are prudent for a government but imprudent for a private company.

Within a decade we have seen oil prices surge to unheard of heights only to fall to the relative depths of today. Was this an aberration? Or are we experiencing the effects on world oil markets of the policy decisions of Saudi Arabia on the level of production that it deems in its own long-term interest? Are we headed toward a sharply higher reliance on Middle East oil? Are we embarked on a "march of folly" as we abandon alternate energy options development and increase our imports from a region of the world we know from recent experience to be among the most politically unstable? Is the marketplace to answer these questions? Are these no longer legitimate questions of Congressional discourse and action?

There appear to be two schools of thought on the future path of oil prices within industry circles. One group sees soft oil markets well into the future, for perhaps a decade or more. Another group believes Saudi Arabia will begin to curtail production once it has supplanted the production of the higher cost producers, which could occur within a much shorter time period.

In the meantime, low oil prices strain corporate cash flows. Investments that don't yield near term results are harder to justify. The investment horizon comes closer. The long term approach is harder to sell.

Mr. Chairman, that is the climate in industry, and I suspect it is the situation you in the Congress face as well.

In industry we accept the realities of the moment. Despite the energy facts that other witnesses have presented to you this morning, the public does not believe there is an energy problem. The Administration position seems to be that any problem that might exist is best left to the market to resolve. For a number of reasons, synthetic fuels projects have gotten a bad name over the course of the past few years. The technical successes that we have had are not widely enough appreciated. We recognize the long lead time required to develop alternate energy options to have available when the inevitable oil squeeze returns. And we accept that the private sector will not step forward in the current business climate to continue the development effort.

Under these conditions, the Council now turns its attention to an assessment of the technological lessons since the oil price run-ups of the 1970s. We feel a responsiblity to provide the government with our advice on how best to proceed and in what directions when, inevitably, the extent of our vulnerability to energy politics once again becomes apparent to the public and our elected leaders.

Mr. Chairman, I applaud you and the members of your committee for holding these hearings and for your efforts to assure that we don't mistake the current period of falling energy prices for long term stability. We look forward to being of assistance to you, the Committee, and the Administration in your efforts to identify promising areas of research support.

Mr. **Fuqua**. Thank you, Mike. I think Walter Flowers would have agreed with your statement and said amen to it.

Mike, you mentioned the Great Plains project. Can you further elaborate on its significance as an operating project and as a data point for future synthetic programs when they become necessary? And I think we all recognize that they will become necessary along the way.

Mr. **Koleda**. Yes, Mr. Chairman, I would be happy to. I will simply preface my remarks by saying that I am not now here reflecting the council's views on that project. We don't take views on specific projects, but I will give you my own views from kind of what I hear and what I have seen myself.

No. 1, we have a huge project out there. What we have done is taken a gasification, coal gasification technology, the base here is lignite, and we have put it in at commercial scale, the first time in this country that we have done that. Technologically it works. It was built on time. It was built within cost. I think that, No. 1, is a very positive development.

As I indicated, there are some problems. There are some odor problems that I don't fully understand technically, but I have heard the term mercaptan used. I am told it was one of the most noxious odors you will ever, ever have the pleasure to smell. They have got to work on that. The country has got to work on that if this technology is going to move farther ahead.

We have in Great Plains a product which is well overpriced, given current costs of natural gas. We recognize that. However, as a result of some of the happenings this past fall, the debt has been eliminated on that project; and the cash flow does appear to be sufficient to cover operating costs. So, we are in an interesting situation of having a full-scale coal gasification laboratory, if you wish to look at it that way, in place in Great Plains. It is a facility that I would think this committee and others ought to take a look at to see what kinds of additional slip-stream research projects or technology developments can be put in place on that site, because you do have a full-scale operating project in place.

I think there has been a lot of negative talk about Great Plains, white elephant. No question you can't sell that gas in the market competitively. But you do have a research base project for us to learn a lot more from. And I think if we began to think of it more in that way that we would be thinking of it more usefully and correctly.

Mr. **Fuqua**. Also, when that project was being developed, we were anticipating that oil prices were going to be around $40 a barrel at this time or probably even higher, which changes the whole economic situation.

Mr. **Koleda**. And that situation, I would hate to tell you, looking back 10 years, that there isn't anybody who can come here and tell you for sure that that situation isn't going to be back upon us in the future. But we have got quite an investment out there. I think we could make much better use of it than just trying to shed it as if it's some problem in the family that we have got to somehow hide in the closet. I think it's an asset, and we ought to be thinking of it more positively.

Mr. **Fuqua**. A very good point.

Dr. Mechlin, you talked about fuel cells in your testimony. How far along relative to each other do you think the molten carbonate and the solid oxide fuel cells are?

Dr. **Mechlin**. The solid oxide has started out as a third generation technology and is often identified in that respect. I believe, however, the technical progress has brought both of them to a comparable state of development. Indeed the solid oxide is moving very rapidly in terms of proving out its promise.

I think they are even now, and the solid oxide is gaining.

Mr. **Fuqua**. Dr. Mannella, how receptive do you think the public utility community is going to be to the clean coal technology program notice, the PON notice that was sent out, particularly since the modification and the less restrictive payback conditions?

Dr. **Mannella**. Mr. Chairman, as you know, the industry has been quite supportive of that concept over the past several years while the various hearings were held and the legislation was in process. There was a very high level of expectation at the time of the issuance of the draft PON. I think that I would have to observe that there was quite a negative reaction when the details were fully understood. That sort of culminated in a meeting that was held about, I believe, 3 weeks ago tomorrow.

But since the correction of the PON in terms of the payback from profits as opposed to revenue, I think that a large measure of confidence has been restored. We do know of certain consortia that are being put together that will respond to the PON as it stands now, assuming there are no more unpleasant surprises that come upon us, perhaps this Thursday at the bidders conference.

I would also have to say that I don't think the response will be as vigorous as it was to the original notice that was published a year ago, but we are hopeful that it will be sufficient to sustain a meaningful program.

Mr. **Fuqua**. What further justification is there for the continued DOE participation in the advanced fluidized bed combustion program? It seemed to me that, with the clean coal technology initiative, that would be adequate to provide for that last step of commercialization. Could you comment on that?

Dr. **Mannella**. Well, I think, in terms of the utility scale demonstrations that are so critical to moving the technology to the marketplace, that clearly the clean coal technology program fills the major requirement.

One thing we have to remember, though, is that, as these technologies, atmospheric fluidized bed, fuel cells, what have you, move into the commercialization or the precommercialization phase, there is still a need for ongoing R&D. And particularly in the case of atmospheric fluidized bed, I think that it is very attractive to keep certain bench scale and laboratory scale equipment available for the possibility of solving some unexpected problems that might occur during the demonstration phase. So it will be easier, quicker, and cheaper to resolve some of these technological issues that come up at the laboratory scale than in the actual large-scale field demonstration.

Mr. **Fuqua**. Mr. Boucher.

Mr. **Boucher**. Thank you, Mr. Chairman.

Dr. Mannella, I was pleased to hear your optimistic view of participation by the electric utilities in the clean coal technology reserve as it's presently configured. Would you care to make an estimate of about how many proposals might be submitted? I have heard the figure 60 batted around. Is that in the ball park?

Dr. **Mannella**. I really don't have any basis for making an estimate of the number. As you know, we did respond to the original notice over a year ago and listed in our response every conversation that we had at that time with anybody who was interested in the program. That was before it was well defined.

The only thing that I can observe is that, you know, clearly that is the upper limit. Many have dropped out over the last year and a half for various and sundry reasons. In one instance, for example, the pressurized fluidized bed facility at Curtiss Wright up in New Jersey no longer exists. At the time a year ago, one of the utilities was interested in proposing a program to take place there. So, that is a case where just physically the facility is no longer in existence.

Mr. **Boucher**. EPRI was one of the principal entities that was responsible for the successful effort last year to have this program placed on a sustained footing with a $400 million 3-year appropriation. Are you persuaded, as Mr. Bauer was in his testimony, that, given its present configuration as a loan to participating entities with paybacks to be made out of profits, that we will have a viable program, that there will be enough participants to make it workable?

Dr. **Mannella**. I can only give you my own personal impressions. When you look at the type of proposals that are apt to come forth in response to that PON, each project will be a consortium. A consortium will probably consist of a host utility, an A&E firm, an equipment manufacturer, support contractors, and what have you. The various members may have different attitudes toward that particular issue. As far as the utility is concerned, I don't think it makes that much difference because really, as Mr. Webb said earlier this morning, the electric utility does not enter into this with the idea of making a profit but to provide themselves with more technological options for the future.

So, their attitude may not be the same as, say, the equipment manufacturer or the process developer. But I think that, as far as the electric utilities are concerned, it doesn't make that much difference.

Mr. **Boucher**. Let me ask you a question on an unrelated subject. Today there is very little incentive for coal companies to apply technology or for utilities, for that matter, to apply technology which will result in a reduction of ash and sulfur content beyond the point that is necessary to meet utility effluent limits.

There is no reason really today to use a cleaner burning coal than you have to to meet environment requirements. Some people have suggested that there may be an economic justification for going beyond that point, that perhaps utilities can experience a longer life for their equipment. Perhaps the coal can be burned more efficiently if it's cleaner. And I understand that EPRI is doing some research to prove whether or not that is correct.

Can you give us some indication of when we might have an answer to those questions?

Dr. **Mannella**. I really can't claim to be familiar enough with the work going on in that area. I can get you an answer for the record.

But in the past several years EPRI increasingly applied its resources to plant availability, to plant reliability, to plant life extension, not only only after the fact but before the fact, what you have to do in order to be able to extend plant life. And I will have to try to get you some specifics on that, Mr. Boucher.

Mr. **Boucher**. Thank you. I look forward to getting that.

[The information follows:]

EPRI has had qualitative indications of possible economic benefits of cleaned coal for several years. Recent results from combustion tests at the Clean Coal Test Facility suggest that there may be substantive benefits in improved availability, performance and reduced operating costs.

To date, EPRI has preliminary results involving two coals. Our R&D plan calls for characterization of twelve coals over the next three years. This should provide sufficient information to make general projections regarding economic benefits of cleaning representative coals used by the electric power industry.

Mr. **Boucher**. Mr. Mechlin let me simply ask you if you think Westinghouse would have some interest in participating in the proposal that is now forthcoming from the Department of Energy, that we create a new mechanism of delivering Federal basic research dollars. And that is that we have a consortium of two or more companies that together would supply more than 50 percent of the funding, with the Government being the minority partner.

Dr. **Mechlin**. I think I would take the same position on behalf of Westinghouse that has been expressed by a number of the other speakers. The optimum posture of these venture consortia is in the demonstration arena, and an attempt to substitute the venture mechanism in the research arena is not at all appropriate, and is very unlikely to do anything other other than further depress the very sad state of the research efforts that exist already.

Mr. **Boucher**. A related question, What do you think of the administration's request for reduction in funding for basic research for fossil fuels on the order of 72 or 73 percent?

Dr. **Mechlin**. In a very general sense let me say that when one visits this city, it certainly comes to mind that there is a quite broad range of views on the issue of the Government's role in energy, and in many other things. The private sector, the business sector is somehow viewed as much more monolithic in character. In fact, that is not the case. There is in the private sector as great a range or diversity of views as one finds in the city.

Those of who have been engaged in energy research, and in particular, coal utilization, find our credibility is increasingly taxed. And at this point the coal research community that exists in the private sector has become a very sorry state of believability.

So this continued vacillation or probably retreat from coal research by the Federal sector is well on the way to extinguishing it in the whole country.

Mr. **Boucher**. Thank you for your answer.

Mr. Koleda, I have already exceeded my time, but let me just make one point with you.

I was interested in your statement that Great Plains is the commercial scale classification facility in existence, perhaps, I misunderstood. I am very much aware of Tennessee Eastman facility in Kingsport which produces acetic anhydride in a commercially competitive way. So not only is it commercially structured in terms of scale, but it is actually competitive in the market.

Mr. **Koleda**. I think you are quite correct in pointing that out. There is the Tennessee Eastman project that you mentioned, there is also the cool water coal gasification combined cycle project in California.

I guess what I was driving at is this is a particularly large facility and, perhaps, I better say it is the largest coal gasification project underway. You are quite correct.

Mr. **Boucher**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Mr. McCurdy.

Mr. **McCurdy**. No questions.

Mr. **Fuqua**. Thank you gentlemen very much for being here this morning, and we appreciate your comments as we try wrestle with this problem that has to do with budget reduction. Thank you very much.

[Additional questions and answers for the record follow:]

EPRI
Electric Power
Research Institute

March 18, 1986

Hon. Don Fuqua, Chairman
Committee on Science & Technology
U.S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, DC 20515

ATTENTION: Mr. Bill Harvey

Dear Mr. Chairman:

In response to your letter of March 5, 1986, requesting answers to five additional questions for the record of the hearing of March 4, I am pleased to forward the attached material.

The Electric Power Research Institute appreciates the opportunity that you and the sub-committee on Energy Development and Applications have afforded us to discuss our views on fossil energy R/D. Please do not hesitate to contact me if we can be of further service.

Sincerely,

Gene G. Mannella
Director, Washington Office

GGM/skl

1800 Massachusetts Ave., NW, Suite 700, Washington, DC 20036 Telephone (202) 872-9222
Headquarters: 3412 Hillview Avenue, Post Office Box 10412, Palo Alto, CA 94303 (415) 855-2000

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Department of Energy (DOE)
FY 1987 Authorization Request for
Fossil Energy

March 4, 1986

Additional Questions for the Record

Dr. Gene Mannella:

Question 1:

To what extent has EPRI sponsored fuel cell activity in the past, which processes were investigated, what is the present status of your fuel cell program, and what are your plans in the immediate and not-too-distant future?

Answer:

EPRI has expended over $70 million in fuel cell R/D since its inception. Most of this has been on phosporic acid ($43 million) and molten carbonate ($27 million) technologies. A small amount (less than $2 million total) has been expended on alkaline and solid oxide electrolyte technologies.

Fuel cell R/D expenditures in 1986 are estimated to be $4.7 million, continuing the approximately 60% phosphoric acid and 40% carbonate split as in the past. We expect these expenditure rates to continue for the next several years.

EPRI participation (beyond R/D support) in the commercial prototype demonstration programs proposed by IFC and Westinghouse will be strongly influenced by the needs of utilities participating in the programs. Discussion with utilities of possible EPRI roles has begun.

Question 2:

We have heard that the Cool Water Gasification Combined Cycle facility, sponsored primarily by EPRI, has been quite successful. To what extent is the public utility industry considering design, construction and operation of such facilities, and in what time frame?

Answer:

Activity within the electric utility industry with regard to seriously considering constructing and operating coal gasification combined cycle (GCC) plants as their next capacity increment has increased exponentially since the successful start-up and operation of the Cool Water facility. Prior to the operation of the Cool Water plant, not one utility had formally included a GCC plant in their expansion plan.

At this point in time, Potomac Electric Power Company has announced that their next increment of capacity (scheduled to start coming on line in the 1994-1995 time frame) will be a phased GCC power plant. Of ten other utilities working together with EPRI through the Utility Coal Gasification Association, a large majority have identified some form of phased GCC plant as the most attractive next increment of capacity for their systems (scheduled to come on line in the 1993-2000 time period). Some of these utilities have formally changed their energy plans to reflect the introduction of a GCC plant in the early to mid-1990's. EPRI is aware of at least five additional utility companies that are currently seriously considering the design and construction of GCC facilities.

Based primarily on the success of the Cool Water GCC plant, Virginia Power joined with EPRI, Bechtel, Consolidation Coal Co., British Gas, British Oxygen and Babcock, Woodall, Duckham to submit a proposal to the SFC to design and construct a 180 MWe GCC plant at Virginia Power Company's Chesterfield station. This plant would have come on line in 1992.

Question 3:

What amount of support will EPRI provide for the Wilsonville liquefaction pilot plant in FY 1976?

Answer:

Because of tightly constrained 1986-87 budget, EPRI is no longer able to continue its traditional 1/3 share of funding for Wilsonville. However, we are cooperating with Amoco in an attempt to organize a private sector consortium that will provide support to the Wilsonville project. Amoco has participated with EPRI in supporting the 1984-86 program. Initial responses from a number of energy and engineering companies that have been approached have been positive. It is believed that within the next month, such a consortium could be successfully established. If the effort succeeds, EPRI would anticipate contributing about $300,000 for 1987 Wilsonville support along with each of the other members of the consortium with the balance required being provided by DOE.

Question 4:

Please describe the Grimethorpe, England, testing in which EPRI and DOE will participate.

Answer:

The Grimethorpe PFBC pilot is currently operated by the British Central Electricity Generating Board and the National Coal Board. Capital and operating costs invested in the facility to date are about $90 million. EPRI plans to sponsor the design, installation and testing of a 10 MWe size PFBC hot gas filter module to verify the technical and economic feasibility of sintered and fabric ceramic filters for particulate removal from a PFBC combustor compressor. DOE will sponsor the installation and testing of a coal water slurry firing system in 1987. In addition to the results of the filter and slurry firing system tests, the U.S. sponsors obtain rights to the other (proprietary) data being developed at the facility.

Question 5:

In the Clean Coal Technology Initiative, how many demonstrations of various processes do you think will be adequate for demonstration purposes? Atmospheric Fluidized-Bed Combustion? Pressurized Fluidized-Bed Combustion? Integrated Gasification Combined Cycle? Gasification, cleanup, gas turbine, bottoming cycle configuration? What are the smallest sizes of each which will generate data adequate to make decisions for subsequent commercialization?

Answer:

The adequacy of an experience base for the purpose of defining "commercial" status for a new technology is a judgement based on the degree of acceptable risk. For example, EPRI is participating in three full-scale demonstrations of atmospheric fluidized bed combustion that were selected so as to cover a broad range of the utility situations that might be of interest for AFBC - bubbling bed, circulating bed, baseload, cycling service, bituminous coal, subbituminous coal, new plant, retrofit/repowering plant, etc. Thus, when operating experience and performance data are available from all three of these demonstrations in the early 1990s, AFBC should be considered commercially available for similar utility applications.

The value of a demonstration in reducing commercial risk is strongly affected by the test program that is planned for the project and by the availability of supporting small-scale pilot plant and laboratory facilities for inexpensive resolution of technical issues as they arise during demonstration. With a well-planned demonstration plant design, a test program extending over 10,000 hours or more of successful operation, an ability to continue small-scale support and diagnostic testing, and a technology that has only one or two practically applicable configurations, one or two demonstrations might be adequate. Lacking one or more of these criteria, even half a dozen demonstrations might not be sufficient to reduce risks to the threshold for widespread commercialization.

For some industrial applications, a demonstration project of 1/4 to 1/2 the scale of the commercial unit size may be adequate to generate data for commercial design purposes. However, in a highly regulated industry such as the electric utilities, one or more demonstrations at or near full commercial size normally will be required to provide the extended reliability and operability experience for confident commercial design and application. The current capacity needs of the utility industry are such as to generally favor smaller rather than larger unit sizes. As a result, 100-200 MW demonstrations can, for example, generally provide the necessary operating and reliability confidence at a realistic commercial threshold scale.

Specifically with regard to integrated gasification systems, IGCC technology has been advanced by the success of the 100 MW Cool Water project which employs the Texaco coal gasification process. In order to insure that a competitive environment develops it is necessary that other coal gasification processes be proved in demonstration projects. At this time EPRI feels that the two leading process candidates for the next IGCC demonstration projects are the British Gas/Lurgi slagging coal gasification process and the Shell coal gasification process. EPRI is now participating with BGC/Lurgi and others in the funding of a test program on U.S. coals to be carried out in a 600 TPD coal gasification unit at Westfield, Scotland in 1986-87. We are also participating with Shell in their 250-400 TPD coal gasification project at Deer Park, Texas which will become operational in 1987. Each of these activities should be followed by demonstration projects.

EPRI
Electric Power
Research Institute

March 13, 1986

Mr. William T. Harvey
Staff Director
Subcommittee on Energy Development
Room B-374
Rayburn HOB
Washington, D.C. 20066

Dear Mr. Harvey,

The Advanced Power Systems Division of EPRI has responsibility for EPRI's activities in coal gasification and coal liquefaction. Therefore we have prepared the answers to Additional Questions for the Record numbered 2, 3, and 5 posed to Dr. Mannella of EPRI in response to testimony given to the Subcommittee on Energy Development and Applications concerning the DOE FY 1987 Authorization Request for Fossil Energy. These are presented below along with the original questions.

Question 2
We have heard that the Cool Water Gasification Combined Cycle facility, sponsored primarily by EPRI, has been quite successful. To what extent is the public utility industry considering design, construction and operation of such facilities, and in what time frame?

Answer
Activity within the electric utility industry with regard to seriously considering constructing and operating coal gasification combined cycle (GCC) plants as their next capacity increment has increased exponentially since the successful start-up and operation of the Cool Water facility. Prior to the operation of the Cool Water plant, not one utility had formally included a GCC plant in their expansion plan.

At this point in time, Potomac Electric Power Co. has announced that their next increment of capacity (scheduled to start coming on line in the 1994-1995 time frame) will be a phased GCC power plant. Of ten other utilities working together with EPRI through the Utility Coal Gasification Association, a large majority have identified some form of phased GCC plant as the most attractive next increment of capacity for their systems (scheduled to come on line in the

3412 Hillview Avenue, Post Office Box 10412, Palo Alto, CA 94303 Telephone (415) 855-2000

1993-2000 time period). Some of these utilities have formally changed their energy plans to reflect the introduction of a GCC plant in the early to mid-1990's. EPRI is aware of at least five additional utility companies that are currently seriously considering the design and construction of GCC facilities.

Based primarily on the success of the Cool Water GCC plant, Virginia Power joined with EPRI, Bechtel, Consolidation Coal Co., British Gas, British Oxygen and Babcock, Woodall, Duckham to submit a proposal to the SFC to design and construct a 180 MWe GCC plant at Virginia Power Co.'s, Chesterfield station. This plant would have come on line in 1992.

Question 3.
What amount of support will EPRI provide for the Wilsonville liquefaction pilot plant in FY 1987?

Answer
Because of a tightly constrained 1986-87 budget, EPRI is no longer able to continue its traditional 1/3 share of funding for Wilsonville. However it is cooperating with Amoco in an attempt to organize a private sector consortium that will provide support to the Wilsonville project. Amoco has participated with EPRI in supporting the 1984-86 program. Initial responses from a number of energy and engineering companies that have been approached have been positive. It is believed that within the next month, such a consortium could be successfully established. If the effort succeeds, EPRI would anticipate contributing about $300,000 for 1987 Wilsonville support along with each of the other members of the consortium with the balance required being provided by DOE.

Question 5 (in part)
In the Clean Coal Technology Initiative, how many demonstrations of various processes do you think will be adequate for demonstration purposes? Integrated Gasification Combined-Cycle? Gasification, cleanup, gas turbine, bottoming cycle configuration? What are the smallest sizes of each which will generate data adequate to make decisions for subsequent commercialization?

Answer

The need for successful demonstration plant operation for any new technology prior to commercial acceptance by the electric utility is well documentated. A technology must demonstrate inherent reliability, availability, maintainabililty, as well as the potential for economical power generation at a scale of 100-200 MW to be seriously considered by the industry. It is important that all components and processes required to make electricity from coal are integrally operated in a satisfactory way. Even one unsatisfactory item will likely preclude an otherwise successful demonstration program from being accepted as a basis for technology commercialization.

IGCC technology has been advanced by the success of the 100 MW Cool Water project which employs the Texaco Coal Gasification process. In order to insure that a competitive environment develops it is necessary that other coal gasification processes be proved in demonstration projects. At this time EPRI feels that the two leading process candidates for the next IGCC demonstration projects are the British Gas/Lurgi Slagging Coal Gasification process and the Shell Coal Gasification process. EPRI is now participating with BGC/Lurgi and others in the funding of a test program on U. S. coals to be carried out in a 600 TPD coal gasification unit at Westfield, Scotland in 1986-87. We are also participating with Shell in their 250-400 TPD coal gasification project at Deer Park, Texas which will become operational in 1987. Each of these activities should be followed by demonstration projects.

Other gasification technologies in various stages of development at this time will also require successful demonstration projects prior to acceptance by the electricity industry.

If we can be of any further assistance please contact us.

Very truly yours,

Ronald H Wolk for

Dwain F. Spencer
Vice President Advanced Power Systems

DFS/jme

Westinghouse
Electric Corporation

1801 K Street N W
Washington DC 20006

March 18, 1986

Honorable Don Fuqua
Room 2269
Rayburn House Office Building
U.S. House of Representatives
Washington, DC 20515

Dear Congressman Fuqua:

Attached are responses to your March 5, 1986 letter to Dr. George F. Mechlin (copy enclosed).

Westinghouse was pleased to have an opportunity to appear before your subcommittee hearing on March 4, 1986. It is hoped that the information provided is helpful to you and your Committee in its deliberations.

Sincerely,

John A. Gruver
Manager
Government Programs

Enclosure

cc: George F. Mechlin

RECEIVED
MAR 31 1986
COMMITTEE ON SCIENCE
AND TECHNOLOGY

MAR 28 1986

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Department of Energy (DOE)
FY 1987 Authorization Request for
Fossil Energy

March 4, 1986

Additional Questions for the Record

Dr. George F. Mechlin

1. It is claimed that the efficiency of the molten carbonate fuel cell is about 60 percent on a natural gas to busbar basis. On that same basis, what efficiency would you claim for the solid oxide fuel cell?

The solid oxide fuel cell can also be configured at a 60% efficient all electric power plant, that is, utilizing the very high quality heat available from the SOFC generator exhaust gases to raise high pressure steam which would be utilized in a bottoming steam cycle to generate electricity. The electricity available from this plant would be from a relatively simple system configuration using well-known technology and commercially available components.

2. What is the extent of Westinghouse participation in the Waltz Mill Gasification and Hot Gas Clean-up facility? That configuration, consisting of gasifier, clean-up processes, gas turbine, and bottoming cycle, appear very attractive from an overall efficiency standpoint. How soon do you think such a configuration can be made available to the electric utility industry?

Westinghouse is a significant equity participant in KRW Energy Systems and as such continues to have a major interest in the success of commercialization of the technology. Westinghouse continues to provide technical and marketing support to KRW Energy Systems, Inc. for the development of the advanced fluidized bed gasification and hot gas cleaning technology. The Westinghouse R&D Center provides fuel processing, gas cleaning, and materials technology under contract to the "joint venture." The Westinghouse Combustion Turbine Systems Division works with KRW Energy Systems to develop electric power plant cycles and integrated gas turbine systems. The Westinghouse "marketing" contacts with the electric utility industry is utilized to coordinate opportunities with this industry. The technology is ready for demonstration for a combined cycle power plant application.

Council on Synthetic Fuels

March 27, 1986

Honorable Don Fuqua
Chairman
Committee on Science and
 Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

It was a pleasure appearing before the Subcommittee on Energy Development and Applications on March 4 to discuss the federal role in synthetic fuels research and development.

I have discussed with a number of Council members the additional question for the record you posed in your March 10 letter, i.e., is there a need for a national focal point on synthetic fuels to maintain and make accessible information and to plan for and coordinate federal government activities toward the day when we will need to bring on line commercial synfuels plants? My response, based upon those discussions as well as my experiences in Washington dealing with synfuels policies over the past five years, is enclosed with this letter.

With best regards,

Michael S. Koleda
President

Enclosure

1301 Pennsylvania Avenue, N.W. • Suite 325 • Washington, D.C. 20004 • (202) 347-7069

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Department of Energy (DOE)
FY 1987 Authorization Request for
Fossil Energy

March 4, 1986

Additional Questions for the Record

Mr. Michael S. Koleda

With the demise of the Synthetic Fuels Corporation, please comment on the necessity for a synthetic fuels focal point. If such a coordinating, planning, evaluating, and directing entity should be needed to accumulate useful data for possible future use, where should it reside, and under what circumstances?

Answer:

With regard to a central location for data and other technical information in the public domain, I believe that the significant level of public funds expended over the past decade on synfuels research, development and demonstration demands that the federal government assure that such information be maintained and made accessible for future use. This places a major responsiblity on the DOE for information derived from R&D and (as designated under the fiscal 1986 continuing resolution) the Department of Treasury for operating information derived from SFC-supported projects. I would hope that Treasury will make available sufficient resources to adequately discharge its responsibilities in this regard.

With regard to proprietary technical and economic information provided by the private sector to the SFC with project applications, this information is best maintained by the private sector, to be updated and used as conditions warrant.

I see a much more serious problem in the area of human resources. The abolition of the Synthetic Fuels Corporation and the virtual zeroing out of DOE synfuels-related R&D threatened under the proposed fiscal 1987 budget will leave a policy and leadership vacuum in the executive branch regarding the nation's synfuels option. With this we will run the risk of institutional amnesia, erasing all memory of the policy and political lessons learned during the tumultuous life of the SFC. I have no ready answers on how to maintain a cadre of knowledgable, dedicated persons who can provide the leadership and experience when the nation revives the political will to bring synfuels on line.

Mr. **Fuqua**. Our next and last panel, Dr. J. Read Holland, Director, the School of Mines and Energy Development, at the University of Alabama; and Dr. Charles J. Mankin, director of Oklahoma Geological Survey; and Mr. Dave Brown, president of MHD Industrial Forum.

Mr. **McCurdy**. Mr. Chairman, while they are setting up the place cards——

Mr. **Fuqua**. I believe I noticed Dr. Mankin is from Norman, OK?

Mr. **McCurdy**. Norman, OK, that is correct. We have been very privileged to have the chairman in Norman, OK.

And I wanted to welcome Dr. Mankin, who is very much an authority on oil and gas, and energy problems throughout the Southwest, and, I think, throughout the United States.

I wanted to say, Mr. Chairman, that since they are going to go into their speeches, I am going to have to apologize because at some point I am going to have to—I have got a 12:45 speech right downstairs that I have to make—and I just wanted to say we appreciate the gentleman Dr. Mankin, traveling from Oklahoma, to come and testify today. And I have seen your statements and I think they are all very good.

If we don't get to the point where we can ask questions, I wanted to make it clear as to why I was leaving the room. Again, I appreciate the chairman's indulgence.

Mr. **Fuqua**. Dr. Holland.

STATEMENTS OF J. READ HOLLAND, DIRECTOR, THE SCHOOL OF MINES AND ENERGY DEVELOPMENT, UNIVERSITY OF ALABAMA; CHARLES J. MANKIN, DIRECTOR, OKLAHOMA GEOLOGICAL SURVEY; AND DAVE BROWN, PRESIDENT, MHD INDUSTRIAL FORUM

Dr. **Holland**. Thank you, Mr. Chairman. My name is Read Holland, I am the director of the School of Mines and Energy Development at the University of Alabama. The school of mines and energy development conducts a broad range of mineral and energy related research which responds to the national need and the state need.

In carrying out this mission the university has committed substantial funds and human resources to this research aimed at the development of the resources and processes for improving our energy and minerals posture. So we come to you not emptyhanded.

We have invested a large number, a large amount of our state resources in this endeavor relative to fossil energy.

I would like to depart from my prepared remarks for just a moment, and make some comments on some things that have been said today.

One, when we look at the—I am going to talk specifically about oil shale today, but—when we look at the request from the Department of Energy for oil shale of $3.6 million, this is certainly a subcritical level, it is unacceptable, and there is no way we can move ahead into the oil shale arena at that level of funding. Further it completely cuts out any consideration of eastern oil shale, which we think is a very important resource, and I am going to speak to that particularly.

I would also like to remind you that, as it has been said today, the current situation in the world oil price and the world oil market, provides us with a window to shore up our technological base for the next round of energy problems, particularly in the liquid hydrocarbon area. I think, it is particularly important for us to move ahead at this time.

There is apparently some lack of strategic planning within the Department of Energy as reflected by their comments today. I think that is deplorable. I commend the committee and the Congress for its efforts to invoke some level of strategic planning on the budgetary process within the Department of Energy.

I think the Department of Energy has lost sight of the fact that universities have a role in terms of, not only research, but that is greatly closely linked with graduate education, and without the research dollars the graduate education doesn't occur at an appropriate level. Without the graduate education you don't have trained pool of skilled manpower necessary to move this enterprise forward. And I think it is vastly overlooked in their projection.

Let me return now to my testimony, or the thrust of testimony. My testimony really assumes that we are going to be able to get rid of the deferral problem that we now have, because if we don't get rid of the deferrals the Eastern Oil Shale Program is already disassembled.

But assuming that we can, there are some things that ought to be done within the Eastern Oil Shale Program. I have been asked to comment on the impact of the reduction of the program of about 15 percent, certainly that is much more acceptable than the 71 percent reduction that has been suggested.

This oil shale base is a very large resource base. Let me point out that just in the eastern part of the United States that it is about 400 billion barrels of known resources. Whereas the possible extensions of the resource that would come about through the application of a sound R&D program, this could be extended out to 2.6 trillion barrels of oil resource in the eastern part of the United States.

At the 400-billion barrel level, this would represent an 84-year domestic supply, exclusive of any other conventional source of oil, or imports. So I think it is a viable resource that needs attention.

I also think it has a possibility of being economically competitive. I think we are looking at the potential of $25 a barrel for eastern shale oil as compared to the DOE projections of $45 to $55 a barrel for western shale oil. Now there are a number of reasons for that, and I am going to go into that.

But assuming that we can put together a reasonable program at the 15-percent reduction level, 15-percent reduction from $12,136,000, would give you a base of $10,316,000. At that level you can maintain a viable Eastern Oil Shale Program albeit to reduce the progress, but it is still viable. But you need to do some redirection within the program and some reprogramming is absolutely essential.

We would suggest to you that there needs to be—that we should have a $3,816,000 Eastern Oil Shale Program, specific eastern oil shale; a $5,983,000 base technology program; and a subprogram on environmental mitigation of $517,000, giving you this total. Now at this level we think you can move ahead, but the support has to be very selective, very specific, and represent a realistic energy opportunity. Because of our work, for a number of years in the shale area, and the fossil energy areas, we feel like we can make some comment on what the priorities ought to be.

We acknowledge that in the State of Alabama we have a vested interest in this process because we have a fairly large oil shale reserve in the northern part of the State. And we consider them to be essential to the future economic health of the State.

There is a lot of evidence around that western shales and eastern shales are significantly different. Let me point out some of those differences, and that is the basis for our argument for a specific eastern oil shale research subprogram.

For example, eastern oil is leaner in oil yield as measured by conventional assay technique, the Fischer Assay technique, because of an inherent hydrogen deficiency.

There is abundant organic carbon in the eastern shale. And that coupled with the hydrogen deficiency indicates a need to add hydrogen during subsequent retorting for the recovery of the shale oil.

On the other hand, the lower carbonate content of the eastern oil favors some potential oil recovery processes, such as supplemental hydrogen production via the water shift reaction. This would not apply to western shale. Also the lower carbonate content of the eastern shales requires a lower thermal input during retorting; this gives a decided advantage.

All in all, these differences, the presence of abundant water sources; proximity of the the market and refineries; and availability of skilled labor supply, tend to offset many of the presumed economic advantages of western shale. And it is on this basis that we make some of our economic projections.

As we say, we are encouraged by the recent results on eastern shale. And we feel that with further research and development it is now probable that we can get the cost down to $25 a barrel, and perhaps somewhat lower than that. But that begins to put it on a very much different economic footing than it now is.

The prospect of dramatically improved economics for eastern shale, we feel, justifies continuation, however, and a modest increase in the funding for research specific to eastern oil shale.

At the funding level of $3,618,000, we have some ideas of what should happen. One of the things that should happen within that context is continuing beneficiation and the hydrogen retorting studies, now underway.

We should continue to support the innovative processing on eastern oil shale through the recent program research and development announcement, at a level of about $1.2 million.

We should do characterizations studies of eastern oil shale and the products from eastern shale. And it should study some of the innovative processes related to retorting of eastern shale.

For the oil shale technology base we recommend $5,983,000, which is a decrease from the current level of $6,447,000. One way you can accomplish this is to discontinue the present studies of in situ processes and fragmentation modeling now being conducted, they don't seem to be going anywhere, or offer a very low promise of success. And that is about $3 million there.

The solids recycle chemistry and modeling can be reduced and moved to Morgantown, as the Department of Energy recommends in their budget request. These modifications then, these reductions, and reprogramming, would allow the Department of Energy to undertake some new work on innovative processes and to conduct a very important study, we feel, on the nonfuel mineral values present in oil shale.

To be specific there are strategic mineral values at present in eastern oil shale, in oil shale, particularly, eastern oil shale, but in all oil shale, such as vanadium, molybdenum, cobalt, nickel, titanium, uranium, some of which are on critical materials list, and we feel that those can be recovered during the processing.

Let me tell you that beneficiation of shale concentrates the kerogen rich portion of the shale to economically attractive levels. In that kerogen rich portion that you are going to process, you will also have many other mineral values of interest from the list that I just pointed out.

We feel that there is a potential for secondary product streams that have strategic importance to this country, as well as economic importance to eastern oil shale process, or shale processing.

In the area of environmental mitigation, we feel this can be cut dramatically because the environmental concerns tend to be process specific, and site specific, and until the technologies improve to the point that sound economic and technicial decisions can be made, environmental studies can be reduced pretty much to a core level, and the core level is about $517,000 recommended by the Department of Energy to be conducted at Morgantown.

We strongly endorse continued funding of a national oil shale effort, including a specific Eastern Oil Shale R&D Program that was initiated last year. And we urge the appropriation of a very modest $10,316,000 budget, as a minimum budget for continuation of the program in fiscal year 1987.

Let me emphasize that the program we recommend begins to refocus on the eastern oil shale. And it also has potential to greatly extend the resource base and dramatically improve the economics of shale oil recovery.

Thank you for allowing me up to present my views.

[The prepared statement of Dr. Holland follows:]

Statement by Dr. J. Read Holland, Director
The School of Mines and Energy Development
The University of Alabama
Before the House Subcommittee on
Energy Development and Applications
Hearings on Fiscal Year 1987 Authorization for the
Department of Energy's Fossil Energy Programs
March 4, 1986

This testimony pertains to FY 1987 Department of Energy R&D Appropriations for oil shale research. The University of Alabama strongly endorses the continuation of oil shale research at a realistic level of funding and offers a plan under which an effective R&D program can be continued at a funding level below that appropriated to the Department of Energy in FY 1986.

Mr. Chairman and Members of the Subcommittee:

My name is J. Read Holland. I am Director of the School of Mines and Energy Development (SOMED) at The University of Alabama. The School of Mines and Energy Development conducts and supports mineral and energy related research which responds to state, regional, and national needs. In carrying out this mission, The University over the years has committed substantial funds and human resources to research aimed at development of resources and processes for improving the nation's energy and minerals supplies. One area of activity has focused on processing and extraction of oil shale for production of unconventional crude oil.

The oil shale deposits in the Green River formation of Colorado, Wyoming, and Utah, and the Devonian black shales in the Eastern United States constitute a vast potential resource of unconventional crude oil which in the aggregate account for an estimated oil equivalent of perhaps as much as 168 trillion barrels. The Green River deposits contain the equivalent of over 8 trillion barrels of which about 189 billion barrels can be recovered with existing technology. According to the U.S. Geological Survey, the total "known resources" of oil in the Devonian Eastern oil shales are 400 billion barrels and "probable extensions of known resources" are estimated at an additional 2.6 trillion barrels. At current national consumption levels this 400 billion barrel reserve of Eastern shale oil represents an 84 year domestic oil supply, independent of imports or other U.S. production of conventional crude oil. By application of new extraction technology now under investigation, this oil resource in the Eastern shales would increase by as much as 250 percent. Despite waxing and waning of interest in oil shale commercialization with the sharp swings in crude oil prices, there is an urgent need to continue an innovative research program concerned with the technological development of more economical processes for extracting the oil from our domestic shales. Based on our research results, I believe we can extract Eastern shale oil at a cost of $25 per barrel or lower, thus making shale oil economically competitive.

The FY 1986 Department of Energy appropriation of $12.632 million for oil shale R&D provided a modest level of funding for the support of a viable national Western and Eastern oil shale program. Even with application of a 4 percent reduction of the appropriated funds to $12.136 million under the Gramm/Rudman/Hollings Act, this oil shale program remains viable. With the problems confronting Congress relative to the national deficit and passage of the Gramm/Rudman/Hollings Act, we recommend an FY 1987 oil shale budget of $10.316 million; this is 85% of the FY 1986 budget base. At this level the program can maintain a steady but reduced rate of progress toward development of a strong technological base. A vital core program can be maintained if appropriate adjustments are made. We recommend increasing specific Eastern Oil Shale Research and the generic Base Technology subprogram while making a substantial reduction in the Environmental Mitigation subprogram. Reduction of Environmental Mitigation was suggested in the Department of Energy FY 1987 budget request. Our suggested budget follows:

Eastern Oil Shale	$ 3.816 million
Base Technology	$ 5.983 million
Environmental Mitigation	$ .517 million
Total	$10.316 million

Supporting research to maintain a technological data base for the future is surely one of the responsibilities of the federal government. This, certainly, is a continuing requirement in the case of oil shale under the Department of Energy's current program of long-range and high risk technology development aimed at an assured future energy supply. However, such support must be selective, specific, and represent a realistic energy opportunity. Our review of the oil shale program funding adjusted to the Gramm/Rudman/Hollings Act requires a review of the priorities based on the known technology state-of-the-art.

The School of Mines and Energy Development has been deeply involved in improving our research base on Eastern oil shale, hence we offer our thoughts regarding the priorities for a meaningful oil shale R&D program. In addition to our laboratory research efforts, we continuously monitor activities pertaining to the emerging technologies, research findings, environmental concerns and economic factors that might impact utilization of Eastern shale. We acknowledge that the state of Alabama and The University of Alabama have a vested interest in the federal program on oil shale since our state is blessed with large resources of the shale. Hence, we consider development of this resource as essential to the state's economic health.

There is ample evidence indicating that significant differences exist between the Eastern and Western oil shales. For example, Eastern oil shales are leaner in oil yield, as measured by Fischer Assay, because of an inherent hydrogen deficiency. The presence of abundant organic carbon in Eastern oil shales strongly indicates a need to add hydrogen during oil recovery. On the other hand the lower carbonate content of Eastern oil shale favors some potential oil recovery processes, such as supplemental hydrogen production via the water gas shift reaction. Also this lower carbonate content of Eastern shales requires a lower thermal input during retorting. The presence of abundant water resources, proximity to the market and refineries, and available skilled labor supply, tend to offset many presumed economic advantages of Western oil shale.

We are encouraged by our recent results on recovery of oil from Eastern shales. With further research and development of the technology it now seems probable that Eastern shale oil can be produced at a cost of $25 per barrel or less. This projected cost is much less than a projected Western shale oil cost of $45 to $55 per barrel that the Department of Energy cites in their 1987 budget request. The prospect of dramatically improved economics for Eastern shale oil justifies continuation of, and a modest increase in, the funding for research specific of Eastern oil shale. We recommend a funding level of $3,816,000 for specific Eastern shale research for FY 1987. The FY 1986 Eastern oil shale appropriation is $2,000,000. This recommended funding level should be directed to:

- Continuing beneficiation and hydrogen retorting studies underway at Hycrude Corporation and the University of Alabama ($1,700,000).
- Support for innovative processing on Eastern oil shale through the Program Research and Development Announcement issued 1/15/86 by the Department of Energy ($1,116,000).
- Characterization studies of Eastern oil shale and Eastern shale oil ($500,000).
- Study of water gas shift reaction during retorting of Eastern oil shales ($500,000).

For the generic oil shale technology base we recommend $5,983,000 for FY 1987. This recommended funding represents a decrease on the generic oil shale technology from the FY 1986 base level of $6,447,000. This level will permit continuation of existing generic technology studies at Morgantown Energy Technology Center, Western Research Institute, and Lawrence Livermore National Laboratory. Further we recommend that:

- Present studies of in situ processing and fragmentation modelling be discontinued.
- Solids recycle chemistry and modelling be reduced and moved to METC.

These modifications will permit the Department of Energy to undertake new work on innovative processes and to conduct a study of the other nonfuel mineral values present in oil shale. To be specific, a generic study of the nonfuel mineral values in oil shale, such as uranium, vanadium, molybdenum, cobalt, nickel, titanium, and sulfur, should be undertaken. Beneficiation of oil shale concentrates the kerogen rich portion of the shale to economically attractive levels. This kerogen rich shale concentrate is rich in many other mineral values of interest. Some of these minerals are of great strategic importance and are on the national critical minerals list. The technical and economic feasibility of recovery or separation of these nonfuel minerals should be given careful study. For emphasis, I repeat that this recommended 1987 funding is sufficient to initiate a generic study of recovery of all fuel and nonfuel mineral values from oil shale. In addition to strategic mineral values, recovery of the heavy metals and sulfur may substantially improve the economics as well as significantly reduce the environmental risks.

Further we recommend that environmental mitigation funding be reduced from the FY 1986 appropriation of $3,689,000 to a suggested FY 1987 level of $517,000. We justify this reduction on the basis that environmental mitigation tends to be specific to the technology selected and to the production site. Until the technology is improved to the point that sound technical and economic decisions can be made, environmental studies should be reduced to a core level necessary to maintain a generic program at Morgantown Energy Technology Center. The $517,000 we recommend for FY 1987 environmental mitigation is consistent with the Department of Energy's 1987 budget request.

The University of Alabama strongly endorses continued funding of the national oil shale effort, including the specific Eastern oil shale R&D program initiated in FY 1985, and urges the appropriation of a rather modest $10.316 million budget for its continuation in FY 1987. We feel that is near the minimum level for a meaningful R&D program. Let me re-emphasize that the program we recommend begins to focus on Eastern oil shale. The recommended research program has the potential to greatly extend the resource base and dramatically improve the economics of oil shale recovery. Thank you for the opportunity to present my views to you today.

Mr. **Fuqua**. Thank you.

Dr. Mankin.

Dr. **Mankin**. Thank you, Mr. Chairman. I have prepared a statement, I would ask that it be entered into the record.

Mr. **Fuqua**. Yes, we will make that part of the record.

Dr. **Mankin**. And I would like to simply comment on a few highlights from this presentation.

I have asked if we have a slide projector so that it might help the committee in reviewing some of the comments I wish to make.

[Slide presentation.]

Dr. **Mankin**. I think that it is important for us to recognize that for a very long time petroleum and natural gas have been the principal sources of energy supply in the country. Historically for many years those two commodities supplied about three-fourths of our total energy needs. Today they supply about two-thirds of those needs.

And the Energy Information Administration, in the first slide, you will see indicates by the year 2000, that oil and gas will supply something in the neighborhood of about half of our projected energy demand in the year 2000.

I might comment that my own view is that that is an exceedingly conservative estimate.

But that is not the important issue. The important issue is that petroleum and natural gas are going to be major sources of supply for this country's energy demand for a very long time to come.

It shouldn't be surprising that that is the conclusion because of what we have seen in the development of this country as an energy infrastructure that depends upon the utilization of petroleum and natural gas in a variety of ways. For example, in 1984 the extensive gas pipeline transmission and distribution system supplied more than 13 trillion cubic feet of natural gas, to more than 45 million homes, almost 4 million business and almost 200,000 industrial users.

Any change in the source of energy supply for those organizations and individuals would come at great hardship to them. In addition to that, we can point out that there are more than 170 million vehicles on the Nation's streets and highways, and we have built a very extensive primary and secondary transportation system to utilize the automobile to its fullest extent.

I might facetiously add that based on my experience with Washington, there seem to be only about 85 million parking places so we must keep at least half of the vehicles in motion at all times.

I think it is important that we recognize that this Nation runs on gasoline, and it runs on natural gas, to a very significant degree. It is very important that we remember that we put gasoline in our automobiles, we don't put in BTU's of energy. For that reason I think it is important that we recognize the continuing importance of liquid fuels as a part of the total primary energy needs of this Nation.

Now, given those circumstances, we will have only two sources of supply for liquid fuel. We will either continue to produce some of that domestically; or we will import it. And in some way we will accomplish the objective to receive that energy resource for the Nation.

In the second slide, in figure 2, we can see what happens when we deal with petroleum imports.

Except for petroleum imports the Nation would have maintained a positive balance of trade for every year shown on that graph through 1982.

Even today the cost of petroleum imports is exceeding $1 billion per week. That is not an insignificant factor that needs to be taken into consideration. I think as one looks at that merchandise balance of trade, one sees that falling off the bottom of the scale, and I would think that at least as much attention to that ought to be devoted as we are currently trying to devote to our Federal deficit.

Well, one could say, what are the prospects of maintaining present domestic production?

I would have to come before you and say, unfortunately, if we base that answer upon conventional methods of supply the prospect is not very bright.

In short I think it is fair to say that America is going out of the conventional oil production business. Except for Alaska, in the next slide, the U.S. crude oil production has declined by more than 27 percent since 1970. In fact it has been Alaska that has propped up our domestic production to give us an appearance of a continued constant domestic supply.

During that same period crude reserves in the lower 48 States have declined by almost 28 percent. And finally, during that same period annual reserve additions, in spite of all of the drilling that we have done during that period, annual reserve additions are falling short of corresponding production for all but 2 years.

This decline has affected virtually all of the producing States, and some with the greatest production even more so. I think it is fair from those observations to say that if nothing happens, and this trend continues, America will go out of the domestic oil production business, for all practical purposes, certainly, very late in this century or the very early part of the next century.

But we are not running out of oil. You have heard before and I would like to tell you again that, in fact, we have today in approximately 130,000 fields and reserviors, discovered in this Nation since Colonel Drake drilled the first commercial well in Titusville, PA in 1859, almost twice as much as we have produced.

We have more than 300 billion barrels (next slide). We have more than 300 billion barrels of oil in those existing 130,000 fields and reserviors.

The problem is, in spite of what you heard this morning, we do not have the technology in place to recover more than a minute fraction of that huge resource. I believe enhanced oil recovery is an important answer. But the technology and related information needed to apply that technology are far from fully developed.

As pointed out earlier there are technologies on the shelf, and there are technologies in place that are producing enhanced oil. Steam injection in such fields as Kern River in California, and carbon dioxide in a few ideal fields in west Texas, are successes. Most other EOR operations are limited to laboratory or preliminary field test activity.

The National Petroleum Council after a 2 year, 50-man year study that was published in 1984, found that, if existing technologies could be made to work, and I emphasize, if existing technologies could be made to work, recovery of as much as 7.4 billion barrrels of additional crude oil was possible. This is based on the utilization of technology currently under field test, at a price of $20 per barrel.

The NPC study further found that this figure could be increased to 34 billion barrels, about 10 percent of the remaining resource, by applying expected technology that is not yet fully developed, and at prices up to $50 per barrel.

In the next slide we see that those new technologies, if applied, could substantially defer the declining production from domestic sources of supply.

We have heard a lot today about the subject of whose role it is to supply the research and technology in enhanced oil recovery. And always a logical explanation is to rely upon the petroleum industry.

Let me give two reasons why I think that is inappropriate.

First, it should be recognized that the petroleum industry is going out of the research business, in and of itself. The oil industry ranks 30th out of 32 industrial groupings on percentage of sales and percentage of profits reinvested in research and development.

These companies, and I am talking only about the 10 or 12 largest oil companies, spend only 20 percent of the all-industry composite average relative to pretax profits.

As figure 7 shows, and I don't have that figure up here, only 6.4 cents per dollar of pretax profits. It might be noted that only metals and tobacco spent less on R&D.

A second and even more important reason is that the petroleum industry consists of a small number of very large companies, and a very large number of small companies and independents. In 1984, there were 24,429 active oil and/or natural gas operators in the United States.

Of this number the top 10 major producers accounted for one-half the domestic crude oil production, that includes Alaska and the offshore. And the other half accounted for—the remaining 24,000 accounted for the other half. I might add that of that remaining 24,000, many of those are small companies and independents, and their operations are restricted to the lower 48, by virtue of capital investment, and their other activities.

I could give you a lot of other reasons why I think it would be imprudent to rely upon the petroleum industry to insure continuing supply from that source. However, I believe the information that has been provided provides you with some views in that regard. And I would like to suggest that the Federal Government has an important public role if this Nation is to receive full benefit from the remaining resource base of domestic crude oil. It is a public issue. It is central to the U.S. balance of payments, energy security, and the viability of the producing State treasuries and economies.

Federal support for EOR research began shortly after the energy crisis in 1973, and a number of important programs were initiated. Unfortunately, with this current era of energy complacency, together with soaring budget deficits, we are seeing a steady and continuing decline in Federal support in that area.

I believe the present proposed budget by the Department of Energy, proposed for fiscal year 1987, is both grossly inadequate, and misdirected.

Let me highlight for you on the next figure, a quick examination of the DOE budget.

You will see in the slide research and development is only 41 percent of total DOE budget. Of the research and development budget, weapons and naval reactors are one-half; high energy physics, mostly for SDI, is 22 percent. Nuclear energy supply is 12 percent. And fossil energy is 5 percent of that budget.

Of the energy supply research and development budget, nuclear fuel is nearly two-thirds, the fuel that is supplying a very small fraction of our total energy demand, and by all measures will continue to do so well into the 21st century. And fossil energy is 28 percent. Of the fossil research and development, coal is three-fourths, program administration is 13 percent, and oil, gas, shale and tar sands research and development are collectively 9 percent.

EOR research and development to increase supplies of domestic oil is only 1.5 percent of the fossil energy research and development effort, and only 0.03 percent of the overall budget.

You might ask youself, well, if the Federal Government is not doing this work, surely someplace else this work is going on?

As I have tried to point out that is certainly not happening within the industry, the majors are focusing their attention on the frontier areas, and on foreign sources of supply, and their research is reflecting those needs. The small companies and the independents have neither the capital nor the technological expertise to mount a research effort.

Some States are providing support for EOR research directed toward potential opportunities in their area. Even here an important Federal role consists of providing basic information and analytical models as an intregal part of that research effort.

An important example of the Federal-State partnership in EOR research is the current collaboration by the Interstate Oil Compact Commission, the organization of the Governors of the producing States; and the DOE's Bartlesville Project Office.

Using TORIS, the data base and the models developed from the NPC study, supplemented by additional information from State sources, that activity is making some important analytical results available.

In the next slide is one example of that activity. In New Mexico using carbon dioxide for EOR application, you can see there is an opportunity the State has to examine its potential for enhancing domestic production from using CO_2 in a number of appropriate fields in that area.

By examining that the State can then make appropriate decisions with respect to their incentive structure to decide at what level they wish to participate in this process.

Unfortunately, economic conditions from declining oil prices in these oil producing States are also curtailing some of these important efforts.

I think it is important to recognize the basic research under the proposed DOE program for this area of activity would be largely, if not completely, curtailed. All support for university research in EOR would be terminated.

As noted, industry is reducing funding for research, including grants to universities.

Unfortunately, foreign governments, our major competitors in the global energy markets, see the importance of public investment in oil and gas much more clearly than we do.

While we spent only $45.8 million in 1984 on all Federal oil and gas research, and less in each successive year, Canada and its provinces spent $174 million. The International Energy Agency-affiliated countries combined spent $78.4 million. Japan spent $73.4 million.

Figure 11, shows the comparison of R&D expenditures versus consumption for the United States, Canada, and Japan.

I think the slide itself is dramatic enough without further comment.

While the United States spent only $12,000 per billion dollars of its GDP on oil and gas in 1983; Canada spent $315,000; Norway spent $138,000; and Japan spent $84,000. I could go on.

I think another thing that is important to recognize is how these trends existed through time. In the next slide you will see that in the mid-1970's the United States and other IEA countries collectively spent about the same on oil and gas research.

After 1980 these curves diverge dramatically. By 1984, the IEA countries, other than the United States, outspent the United States sevenfold.

Thus, the U.S. technological advantage that it has enjoyed and has secured our international leadership in energy, could well be overcome by these aggressive R&D strategies.

What kind of implication should we draw from these observations?

It seems apparent that crude oil production in the on-shore lower 48 is becoming increasingly dependent on the activities of the companies and the independents who lack research capabilities needed to develop the technology to maximize hydrocarbon recovery.

The Nation, thus, risks abandoning most of the 300 billion barrels of resources known to be present in existing fields.

I think that will also lead to additional increases in our imports and with all of the attendant problems related thereto.

Let me just summarize these observations and then turn specifically to the budget. If an adequately funded and properly directed program of research in fossil fuels is maintained by the public sector, it is reasonable to expect that the projected decline in domestic production could be substantially offset by enhanced oil recovery. That, in turn, would have a substantial effect on the needed level of imports.

The Energy Information Administration in the next slide has estimated by the year 2010, only 46 percent of the Nation's petroleum supply will be obtained from conventional sources. The remainder must be obtained from some combination of EOR, oil shale, and imports.

What we do here today with respect to the public support of a properly directed Fossil Fuels Research Program will have important consequences on that mix to the year 2010 and beyond.

Let me turn now specifically to our recommendations with respect to the fossil fuel budget.

In the context of a 15 percent cut in overall fossil energy research budget, and assuming a continuation of the Clean Coal Program, I do not feel that without undue hardship to the Coal Research Program greater balance can be restored to the overall Federal Fossil Fuel Program.

I believe that this program can be maintained and we can establish a $50 million program for basic research in those areas that I have been discussing. It is clearly not my position to gut the Nation's Coal Program; it is important, and we must pursue it.

On the other hand, as I have argued, it is important to maintain an adequate supply of liquids and gaseous resources because those are the most critical areas with respect to future sources of supply. It is clear that we have an enormous supply of coal. It is clear we have some technology, not the best in the world to recover it to burn it in a variety of ways. What we do not have is the capability to put coal into the gas tank in an efficient way.

Figure 15 takes a $50 million recommendation by the Interstate Oil Compact Commission and distributes it to the following program areas. Relative to fiscal year 1985 and 1986, it represents an increased priority in enhanced oil recovery.

This is consistent with our view of the dominant U.S. energy problem, the shortage of domestic oil production, and that conclusion is supported by the findings of the National Petroleum Council and other Interstate Oil Compact Commission studies.

Meanwhile it restores funding and advanced process technology, oil shale, and unconventional gas to about their 1985–86 level.

Without commenting in great detail, I believe, that the co-op venture idea, although an appropriate idea in a number of areas, I think, is premature in the area of enhanced oil recovery. And I would recommend that that program not be implemented at this time.

I would like to turn now to an organizational recommendation. At present, DOE's management of the oil, gas, and shale programs is fragmented among a number of DOE offices.

We propose that it be consolidated for coordinated management at the Department's Bartlesville Project Office. There are several reasons for that recommendation that I won't go into in detail. However, it is important to recognize that it would consolidate management of a number of activities that have substantial common resource base.

BPO now manages the EOR and the advance APT programs; previously, it also managed the tight gas program, the largest part of the unconventional gas. Even in spite of the turmoil of defederalizing the Federal facilities under a cooperative agreement with NIPER, BPO has established and maintained a solid relationship with both industry, and with the production States.

While recommending consolidated management at BPO, we recognize that for efficiency in day-to-day operations some personnel might be physically stationed in Laramie, San Francisco, or even Morgantown. Overall, however, we recommend a mandated personnel floor of 35 Federal employees, reporting to BPO, to manage the consolidated program. This is just 10 more than are currently stationed at BPO and the DOE Laramie alone.

This recommendation would require the managerial reassignment of some personnel and some reshuffling of program direction funds; but no overall increase. The program direction budget and the personnel minimum should, however, explicitly display the BPO totals so that you, the Congress, can examine them and comment on them as appropriate.

The final organizational issue is the resolution of the status of Federal research facilities at Bartlesville at the conclusion of the cooperative agreement with NIPER. The DOE budget refers vaguely to privatization of this facility, without specifically describing what DOE plans.

We, however, recommend that these facilities remain Federal property so that they may be used for Federal petroleum research purposes. The most appropriate mechanism once the cooperative agreement with NIPER expires, is to establish a government-owned, contractor-operated, structure at Bartlesville.

This arrangement has been amply demonstrated to be highly cost effective at the national laboratories. NIPER, or its parent, IIT Research, would be eligible to bid on managing the facility, and as an incumbent, would have many advantages in doing so.

Other bidders, however, would also be eligible so that competition that would result would provide high-quality management to the facility to carry out Federal priorities.

In summary, our recommendation moves toward a greater balance among the fuel sources and the fossil energy research budget; seeks consolidated management of closely related programs at the site that has established sound working relationship with the scientists, technologies, and producing States most concerned with these resources; and directs DOE to develop the implementation plans to establish a stable effective program of basic research in oil, gas and shale.

Thank you very much.

[The prepared statements of Dr. Charles Mankin and Susan Wu follow:]

STATEMENT OF DR. CHARLES MANKIN
STATE GEOLOGIST, STATE OF OKLAHOMA
before the
Subcommittee on Energy Development and Applications
House Committee on Science and Technology
U.S. Congress

March 4, 1986

Mr. Chairman and Members of the Subcommittee:

Petroleum and natural gas have been, are now, and will continue to be for the rest of this century and beyond the major sources of our Nation's energy supply. At present, these commodities supply two-thirds of our energy needs and the Energy Information Administration (EIA) estimates they will continue to supply as much as one-half of our needs in the year 2000 (Figure 1). Estimates by others suggest the EIA projection may well be conservative. However, the precision of the EIA estimate is not the important issue. What is important is the continuing major role that petroleum and natural gas are expected to play in supplying our energy needs into the 21st century.

Actually, that conclusion should not be surprising. Petroleum and natural gas have had a long history of serving as this nation's principal sources of energy supply. This has led to the development of an energy utilization infrastructure in this country that cannot be easily nor rapidly modified. In 1984, the extensive natural gas pipeline transmission and distribution system supplied 13.2 trillion cubic feet of natural gas to:

- 45.7 million homes;
- 3.8 million businesses; and
- 189 thousand industrial users.

In that same period, electric utilities received 3.1 trillion cubic feet of natural gas. Furthermore, there are at present more that 170 million vehicles on the Nation's streets and highways that are dependent upon a continuing supply of liquid fuel. In 1983, these vehicles were driven in excess of 1.65

trillion total miles and consumed more that 115 billion gallons of fuel. Truly, Americans have a love affair with the automobile and place an exceedingly high value of their freedom on mobility. Because the internal combustion engine powered by liquid fuels is the primary mode of the transportation of people as well as the principal method of the movement of commodities, any disruption in this system can have major adverse consequences.

Given the circumstances of a continuing demand for these energy commodities, the question arises as to what will be their sources of supply? The answer is relatively simple. We will either produce all or some part of that supply domestically or we will import it from foreign sources. In fact, as is well known, the Nation has been importing crude oil and refined petroleum products in significant quantities for more than three decades. These imports have not been without difficulty. Consider the energy crisis of 1973 and the corresponding shock to our economy of the multi-fold increases in world crude oil prices. Or, consider the huge costs associated with the development of the Strategic Petroleum Reserve as a protection against future supply disruptions. From 1975 through 1984, $17.8 billion has been spent on this as a safeguard. Finally, consider the impact of those imports on the nation's merchandise trade balance. As Figure 2 shows, except for petroleum imports, the nation would have maintained a positive balance of trade for every year through 1982. Even today, the cost of petroleum imports exceeds one billion dollars per week. It should be self-evident that future increases in imports will only further increase the deficit, with corresponding degradation of the Nation's economic, diplomatic, and energy security.

What are the prospects of increasing or even maintaining our present rate of domestic production? Unfortunately, the answer based upon conventional methods of supply is not optimistic. In short, America is going out of the oil-production business. Except for Alaska, the United States' crude oil production has declined by 27 percent since 1970 (Figure 3). During that same period, our proved reserves in the lower 48 states have declined by almost 28 percent. Finally, in that same period, annual reserve additions have fallen short of corresponding production in all but two years. This decline has affected nearly all the producing states and has been most severe in some of those with greatest production (Figure 4). With declining production have come serious losses to their economic and tax bases. Thus, it is not difficult to see that if these trends continue, domestic production will continue to decline substantially and will require correspondingly higher imports to meet our continuing and probably growing demand.

America is going out of the oil-production business, but we are not running out of oil. In fact, we have today, in the approximately 130,000 fields and reservoirs discovered in this nation since Col. Drake drilled the first commercial well in Titusville, Pennsylvania, in 1859, almost twice as much as we have produced. That's correct; more than 300 billion barrels of oil (Figure 5). The problem is we do not have the technology in place to recover more than a minute fraction of this huge resource.

Enhanced oil recovery (EOR) is the answer, but the technology and the related information needed to apply that technology are far from fully developed. Except for steam injection in such fields as Kern River in California and carbon dioxide in a few ideal fields in West Texas, most other EOR operations are limited to laboratory or preliminary field test activities. If the years of research and millions of dollars in field test have taught us anything, it is how little we understand our reservoirs and how EOR processes work in them. After great optimism, we now acknowledge the urgent need for more basic research to learn how to produce these resources.

Yet, the National Petroleum Council (NPC), after a two-year, 50 man-year study that was published in 1984, found that, if existing technologies could be made to work, recovery of as much as 7.4 billion barrels of additional crude oil was possible. This is based upon the utilization of technology currently under field test at a price of $20 per barrel. The NPC study further found that this figure could be increased to 34 billion barrels (about 10 percent of the remaining resources) by applying expected technology that is not yet fully developed and at prices up to $50 per barrel. New technologies, yet to be conceived but derived from basic research, could make still more available. If these technologies can be achieved through basic research, EOR technology has the potential to offset substantially the decline in U.S. production (Figure 6).

What is the public role, if any, in enhanced oil recovery? A logical expectation is to rely upon the petroleum industry to support the needed research to implement fully EOR processes. The industry has done much and continues to do additional work on the several processes involved. However, there are two important reasons why the industry alone cannot be expected to complete the task in a timely fashion. First, it should be recognized that research conducted by the oil industry ranks 30th out of 32 industrial groupings on percentage of sales and percentage of profits re-invested in research and development. These companies spend only 20 percent of the all-industry composite average relative to pretax profits. As Figure 7 shows, that amounts to only 6.4 cents per dollar of pre-tax profits. Only metals and tobacco spent less on R&D. Further, of this amount only 20 percent -- just over one tenth of a cent per dollar -- is spent on oil and gas extraction research, whereas 53 percent is spent on non-energy research and development (Figure 8). Finally, it should be noted that the majority of the 20 percent is not being spent on basic research and development but on developmental engineering and technical service applications to solve specific field problems.

A second reason is that the petroleum industry consists of a small number of very large corporations and a very large number of small companies and independents. In 1984, there were 24,429 active oil and/or natural gas operators in the U.S. Of these, 148 had annual production of at least 1.5 million barrels of crude oil and/or 15 billion cubic feet of natural gas. Another 473 operators had annual productions of at least 400 thousand barrels of crude oil and/or 2 billion cubic feet of natural gas, but less than the larger operators. The remaining 23,808 operators had annual productions less than the intermediate-sized operators. Of this number in 1984, the top 10 major producers accounted for about one-half of the domestic crude oil production and the remaining more than 24,000 producers accounted for the remaining one-half. It is safe to assume that virtually few of the 24,000 producers have any ongoing research efforts, much less research directed specifically toward EOR. Thus, it is important to recognize that there are a large number of oil and gas operators in the U.S. and they have an enormous spread in annual production. Therefore, each group has very different operating agendas and thus the actions of one group do not necessarily reflect overall industry concerns. For example, the major companies are for the most part turning their attention to frontier areas in the United States (offshore and the Arctic) and overseas.

- Shell and ARCO are reported to be selling all but their largest Lower-48 fields to concentrate more in the frontier areas and abroad;
- Research and development is concerned with the problems associated with foreign and frontier resources, and not those of domestic resources; and
- ARCO laid off 1,000 people at its Plano research facility just last month.

These few examples, together with the "merger-mania" and plummeting prices that have beset the industry and have reduced capital available for long-range research and development, illustrate why the major oil companies are finding it increasingly difficult to conduct basic research on long-range Lower-48 petroleum-related issues.

In contrast, the small companies and independents are confined by the reasons of limited capital and experience to the onshore Lower-48. This group, numbering in excess of 24,000 operators, controls a large portion of the smaller fields in the United States that contain at least one-third of this 300-billion barrel resource. Individually, they have neither the capital resources nor the technical expertise to perform the basic research needed for EOR. Yet, they are the source of our future onshore Lower-48 production.

It, therefore, seems evident that the Federal Government must continue to provide support for EOR research and development if the Nation is to receive full benefit from the remaining resource base of domestic crude oil. This is a public issue. It is central to the U.S. balance of payments, energy security, and the viability of the producing state treasuries and economies. Federal support for EOR research began shortly after the energy crisis of 1973 and several important programs were initiated. Unfortunately, the current era of energy complacency together with soaring budget deficits have contributed to a steady and rapid decline of Federal activities in these areas. Moreover, decisions in the Department of Energy (DOE) have further eroded the Federal effort by shifting emphasis from our most important and urgently required sources of energy supply to other energy commodities. In short, the DOE-proposed fossil fuel budget for FY 1987 is both grossly inadequate and misdirected.

An examination of the DOE-proposed research and development budget for FY 1987 reveals the following (Figure 9):

- o Research and development is 41 percent of the total DOE budget.
- o Of the research and development budget:
  - -- weapons and naval reactors are one-half;
  - -- high energy physics (mostly SDI) is 22 percent;
  - -- nuclear energy supply is 12 percent; and
  - -- fossil energy is 5 percent.
- o Of energy supply research and development:
  - -- nuclear fuel is nearly two-thirds; and
  - -- fossil energy is 28 percent.
- o Of fossil energy research and development:
  - -- coal is three-fourths;
  - -- program administration is 13 percent; and
  - -- oil, gas, shale, and tar sands research and development are collectively 9 percent ($28 million).

  EOR research and development to increase supplies of domestic oil is only 1.5 percent of the fossil energy research and development effort and only 0.03 percent of the overall DOE budget.

Do these low Federal budget priorities for our most important sources of fuel supply indicate others are doing the needed research? Unfortunately, no. As described earlier, the major oil companies have the capacity to conduct comprehensive research programs, but these programs are becoming more restricted because of economic conditions and are focused increasingly on technical issues related to the company's international efforts. The smaller companies have neither the needed capital nor the technical expertise to contribute much in the needed basic research.

Some states are providing support for EOR research directed toward potential opportunities in their areas. Even here, an important Federal role consists of providing basic information and analytical models as an integral part of the research efforts. An important example of Federal-state partnership in EOR research is the current collaboration by the Interstate Oil Compact Commission (IOCC), the organization of the governors of the producing states, and DOE's Bartlesville Project Office (BPO). Using the TORIS data base and models (developed from the NPC study mentioned above and maintained by BPO), supplemented by additional information from state sources, important analytic results are being developed to aid individual states in making regulatory and economic incentive decisions about EOR. Figure 10 is an example of some results of such a study for New Mexico using carbon dioxide in an EOR application. Unfortunately, economic conditions in these states are curtailing some of these important efforts.

Several universities have important EOR research efforts underway, and are contributing important results. Even here, however, support for these efforts depends heavily on the DOE Fossil Fuel program and industry. Under the proposed budget for FY 1987, all support for university research in EOR will be terminated. And, as noted, industry is reducing its funding for research -- including grants to universities.

Foreign governments, competitors in the global energy markets, see the importance of public investment in oil and gas research more clearly.

While we spent only $45.8 million in 1984 on all Federal oil and gas research (and less in each successive year):

- o Canada and its provinces spent $174 million;
- o Other International Energy Agency affiliated (IEA) countries combined spent $78.4 million; and

- Japan spent $73.4 million.

Figure 11 dramatically shows the comparison of R&D expenditures versus consumptions for the U.S., Canada, and Japan. While the U.S. spent only $12,000 per billion dollars of its GDP on oil and gas R&D in 1983:

- Canada spent $315,000;
- Norway spent $138,000; and
- Japan spent $84,000.

We spent only 20¢ per capita on oil and gas R&D in 1984 while:

- Canada spent $7.00 per capita;
- Norway spent $2.10 per capita; and
- Japan spent $.62 per capita.

Figure 12 displays these trends over time. In the mid-1970's, the U.S. and the other IEA countries (collectively) spent about the same on oil and gas research. After 1980, these curves diverge dramatically. By 1984, the IEA countries (other than the U.S.) out spend the U.S. sevenfold. Thus, the technological advantage the United States has enjoyed and that has secured our international leadership in energy could well be overcome by these aggressive R&D strategies of our competitors.

What implications should be drawn from these observations? It seems apparent that crude oil production in the onshore Lower-48 states is becoming increasingly dependent upon the activities of the smaller companies and independents who lack the research capabilities needed to develop the technologies to maximize hydrocarbon recovery. The Nation, thus, risks abandoning most of the 300 billion barrels of resources known to be present in existing fields. That premature abandonment will lead to further increases in petroleum imports with the corresponding growth in our merchandise trade deficits and losses in energy security. That increasing reliance on foreign sources of supply will also increase our risks for economic and military security. In effect, the small savings we realize today by not supporting a publicly-funded research program in petroleum and natural gas will be offset in the future by orders of magnitude increases in expenditures for those commodities.

The U.S. developed and has maintained its leadership in petroleum technology largely through the research efforts supported either directly or indirectly by the petroleum industry. That leadership role is being jeopardized by the real decline in industry-sponsored research and the corresponding declining commitment from the Federal government, while foreign nations are expanding their research efforts. If these trends continue, I believe that the U.S. leadership role will be displaced by the end of this century. America may be getting out of the oil business not only in the Lower-48 states, but around the world as well.

An important segment of the Nation's economy and that of many of the individual states is dependent upon the domestic petroleum industry. Unlike a major oil company, neither this Nation nor any of its individual states can either merge or go abroad for future reserves and production. That dependency is underscored by the immediate consequences that petroleum price reductions have had on the Federal government's income from the Windfall Profits' Tax, royalty income from public lands, and corporate income taxes and the corresponding effect on the budgets of the major producing states. For example, in Oklahoma the reduction in petroleum prices is the major factor in the 15 percent projected reduction in state revenue for the coming fiscal year. Already, we have had to institute emergency measures. That $476 million decrease in expected revenue will have serious adverse consequences for all parts of our state government, some of which will be felt for many years to come. Although the consequences of this price reduction are dramatic, it only telescopes in time those same consequences from declining production.

To summarize, a publicly-supported program of research on maintaining a continuing supply of liquid and gaseous fuels is vital to the long-term best interests of the Nation and the states for the following reasons:

- The existing energy utilization infrastructure requires energy in these forms;
- The adverse effect of growing imports on the merchandise trade balance;
- The effects of import dependency on the Nation's economic and military security; and
- The contribution of domestic production to the economy and tax base of the Nation and especially to that of the major producing states.

If an adequately funded and properly directed program of research in fossil fuels is maintained by the public sector, it is reasonable to expect that the projected decline in domestic production could be substantially offset by enhanced oil recovery (Figure 6). That, in turn, would have a substantial.effect on the needed level of imports. The Energy Information Administration (EIA) has estimated that by the year 2010 only 46 percent of the National's petroleum supply will be obtained from conventional sources (Figure 13). The remainder must be obtained from some combination of EOR, oil shale, and imports. What we do here today with respect to the public support of a properly directed fossil fuels research program will have important consequences on that mix to year 2010 and beyond.

Now, let me turn to a more specific discussion of the 1987 Fossil Energy budget.

The Committee staff asked specifically that I address the question of how a 15% reduction from the Fiscal Year 86 budget levels should be allocated.

In my view, a mindless across-the-board reduction would be disastrous, especially in the programs I am here to discuss. These programs have been cut year after year. First went the fat, later muscle and bone. Further cuts, especially given the prior contractual agreements, would begin to excise parts of the brain.

To be more specific, a 15% cut in the EOR budget would have to come from the basic university research and the vital informational and analytical work I discussed earlier. Firm prior contractual and institutional commitments allow no other alternatives. Similar impacts would be felt in the already under-funded tar sands, oil shale, and unconventional gas programs. Just as we are beginning to understand the critically important reservoir and technology problems of these resources, cuts in basic research and analysis only push out the day when these resources will begin to contribute significantly to the energy, security, and economies of the Nation and the producing states.

As I may have implied in my opening remarks, I am here to recommend movement toward a fossil energy research budget that is more balanced among the respective fuels and more in line with the Nation's energy needs. So, to answer the Committee's question, .I must address the full Fossil Energy research -- and demonstration -- budget.

As background, Public Law 99-190 was signed into law in December 1985. Among other things, it appropriated $397.6 million over three years for cost-shared demonstrations of "Clean Coal" technologies. This law represents the recognition by the Congress and the Administration that certain coal technologies are approaching the "proof-of-concept" phase when full scale demonstration of feasibility can be particularly effective. When DOE solicited "statements of interest" from industry in cost-sharing such demonstrations, it received 175 submissions with project values totaling more than $8 billion. This level of interest clearly indicates the passage of some of these technologies from the research to the demonstration phase. So, it is useful to consider the Fossil Energy R&D budget before the Committee today in the context of the previously appropriated Clean Coal Program.

Figure 14 provides this context. In Fiscal Year 1985, before the Clean Coal Program, coal research accounted for 86% of the Fossil Energy research budget. With the advent of the Clean Coal program in Fiscal Year 1986, coal research was:

o 87% of the Fossil Energy research budget;

o 90% of the total DOE budget for fossil energy; and

o 92% of the Federally-sponsored fossil energy research including industrial cost-sharing.

I suggest to you that the basic coal research in FY86 was largely the preparation for the massive Clean Coal demonstration program. The Administration request supports my interpretation by suggesting that basic research in several coal programs be reduced to levels needed to support the demonstration program. They may, however, have gone too far in deference to our current fiscal deficit. In my view, the Clean Coal program may require more basic research support than the Administration has recommended; I would not presume to address this question.

However, in the context of a 15% cut in the overall Fossil Energy research budget and assuming the continuation of the Clean Coal program, I do feel that, without undue hardship to the coal research program, greater balance can be restored to the overall federal fossil fuel program. My recommendation, the last bar on the chart, would increase coal research by more than 2.3 times over the Administration's request. At the same time, however, I recommend the restoration of the budget for basic research in oil, gas, and shale. My concrete recommendation is that $50 million be appropriated for basic research in these resources and technologies. I will be more specific in this recommendation in a moment.

Before I do, however, let me make a few more observations from this chart:

- As I mentioned, my recommendation for basic coal research is 2.3 times greater than the Administration's request;
- Total federal funding for coal research and demonstration would be almost one and a half times larger;
- Federal outlays for coal research and demonstration would be approximately the same as in Fiscal Year 1986; and
- Including industrial cost-sharing, the overall coal research and demonstration effort would be almost 10% larger than in Fiscal Year 1986.

Clearly, it is not my position to "gut" the Nation's coal program; it is important and must be pursued. On the other hand, as I have argued, basic research to make the Nation's domestic liquid and gaseous resources producible must not be slighted.

Based on resolutions of the 30-state Interstate Oil Compact Commission (IOCC), the Southwest Regional Energy Council (SREC), and my own observations, a basic research program of $50 million is the minimum defensible level. If anything, it is too small to restore a true balance or to meet the minimum requirements, but, after years of serious budget cuts, the amount is about the level that can be cost-effectively managed in Fiscal Year 1987 without untoward growth in the Federal bureaucracy. This level of funding is less than 20% larger than the program in Fiscal Year 1985; in current dollars, it is nearly the same. In future years, I would hope to see this budget increase.

Now, let me turn to more specific recommendations. They address two very different aspects:

- The most desirable level of funding in each of the liquid and gaseous R&D areas; and
- The most appropriate organizational framework under which to conduct this vital research.

Figure 15 takes the $50 million recommended by the IOCC and the SREC and distributes it according to program areas. Relative to Fiscal Years 1985 and 1986, it represents an increased priority in enhanced oil recovery. This is consistent with our view of the dominant U.S. energy problem -- the shortage of domestic oil production -- and the findings of the NPC and IOCC studies. Meanwhile, it restores funding in advanced process technology, oil shale, and unconventional gas to about their 1985-86 levels.

In each case, our recommendation is substantially more than the DOE request. The net effect of DOE's recommendations would be to essentially eliminate the basic research outside of NIPER, WRI, and METC, where DOE has long-standing contractual and institutional obligations. It would eliminate the basic research conducted by universities, National Laboratories, and contract research organizations. It would terminate the informational and analytical assistance now so successfully being applied to assist the states. These impacts must be avoided.

A new element, the Cooperative Venture Pool, has been suggested by DOE for Fiscal Year 1987 This idea would provide Federal cost-sharing to industry-formed, multi-company cooperative R&D consortia in applied technology development and demonstration. Now, I certainly am not opposed to applied research and demonstration, but we must recognize three factors:

- For an industry consortium to find a particular technology interesting, that technology must be near the "proof-of-concept" phase of development; but the requirement in oil, gas, and shale is for basic research, as best done under the more traditional procedures by universities, National Labs, etc.
- To dilute basic research funding in favor of development and demonstration runs directly counter to the policy of high-risk, long-range basic research that the Administration espoused in its last National Energy Policy Plan.
- It is from basic research, not applications and demonstrations, that the fundamental new knowledge that could lead to technological breakthroughs will come. Recent progress in oil, gas, and shale research has shown us how little we really know and has underscored the need for basic research.

If, as I believe, we must live within stringent budget constraints, we must trade-off. If there were no constraints, I could endorse an applied element within a comprehensive R&D program. However, we cannot -- must not -- sacrifice basic research for demonstrations.

While I see other problems with the Coop Venture idea -- the historically low level of investment in R&D by the industry, the difficulties in forming multi-company consortia, the inconsistencies in philosophy between focused federal priorities and industry-initiated projects, the number and complexity of the regulatory "strings" under these arrangements -- these pale into insignificance when such a proposal is advanced at the expense of the basic research so urgently needed.

Thus, in light of the budget situation, our recommendation suggests only sufficient funds for basic research. Our $50 million recommendation is, we believe, the minimum that is required to begin the restoration of a balance for basic research in the Fossil Energy budget. Only if significant additions to total funding were to be made available could we endorse the Coop Venture concept. Reallocation of the Coop Venture funds to basic research is one of our principal recommendations.

Now I turn to our organizational recommendations. At present, DOE's management of the oil, gas, and shale programs is fragmented among a number of DOE offices. We propose that it be consolidated for coordinated management at the Department's Bartlesville Project Office (BPO). There are three reasons for this recommendation:

First, there are a large number of scientific and technological issues that are common or closely related among the respective resources. Consolidation of the management of these programs could exploit these synergies to accelerate progress while improving cost-effectiveness of all the programs.

Second, because of the split in management, significant advocacy for these resources, internal to DOE, is difficult to sustain. In fact, several of these programs are now managed by an office whose principal priority is coal research, perhaps contributing to the historical imbalance of Fossil Energy research budgets. An office whose only responsibility is oil, gas, and shale could better articulate the issues affecting these resources in DOE's internal decision-making.

Third, the vast majority of the Nation's oil, gas, and shale resources lie in the Mid-Continent and Western regions. For the programs to be successful, close and effective communications must be established with the scientists and technologists who will ultimately apply the technologies to produce these resources. Equally important, effective communications with the largest producing states and their multi-state agencies must be maintained to assure that their geological, conservation, and tax agencies and their universities can all contribute their part. The IOCC project I mentioned earlier, which has benefited greatly from BPO's assistance, has resulted in a rational, fruitful dialogue between industry and the State of New Mexico as they jointly address the problems of EOR in that state.

BPO now manages the EOR and APT programs; previously, it also managed the tight gas program, the largest part of the unconventional gas program. Even despite the turmoil of defederalizing the Federal facilities under a Cooperative Agreement with NIPER, BPO has established and maintained solid relationships with both industry (e.g., biennial joint DOE/SPE symposia on EOR; and BPO's serving as the central computing facility on the NPC study) and with the producing states (e.g., the IOCC project).

While recommending consolidated management at BPO, we recognize that, for efficiency in day-to-day operations, some personnel might be physically stationed in Laramie, San Francisco, and/or Morgantown. Overall, however, we recommend a mandated personnel floor of 35 federal employees reporting to BPO to manage the consolidated program. This is just ten more than are currently stationed at BPO and the DOE office at Laramie alone. This recommendation would require the managerial reassignment of personnel and some reshuffling of program direction funds, but no overall increase. The program direction budget and the personnel minimums should, however, explicitly display the BPO totals so that Congress can examine them.

A final organizational issue is the resolution of the status of the Federal research facilities at Bartlesville at the conclusion of the Cooperative Agreement with NIPER. The DOE budget refers, vaguely, to "privatization" of this facility, without specifically describing what DOE plans. We, however, recommend that these facilities remain Federal property, so they may be used for Federal petroleum research purposes. The most appropriate mechanism, once the Cooperative Agreement with NIPER expires, is to establish a government-owned, contractor-operated (GOCO) structure at Bartlesville. This arrangement has been amply demonstrated to be highly cost-effective at the National Laboratories. NIPER (or its parent, IIT Research Institute) would be eligible to bid on managing the facility and, as incumbent, would have many advantages in doing so. Other bidders, however, would also be eligible, so the competition would result in high quality management of the facilities to carry out federal priorities. Whoever was successful in this competition should be able to contract for outside work (with appropriate facilities charges to avoid subsidization and recoup Federal investments). We recommend that DOE be directed to develop a detailed plan for converting the Bartlesville research facility to GOCO status. This plan should be submitted for Congressional review and approval before the end of the current fiscal year.

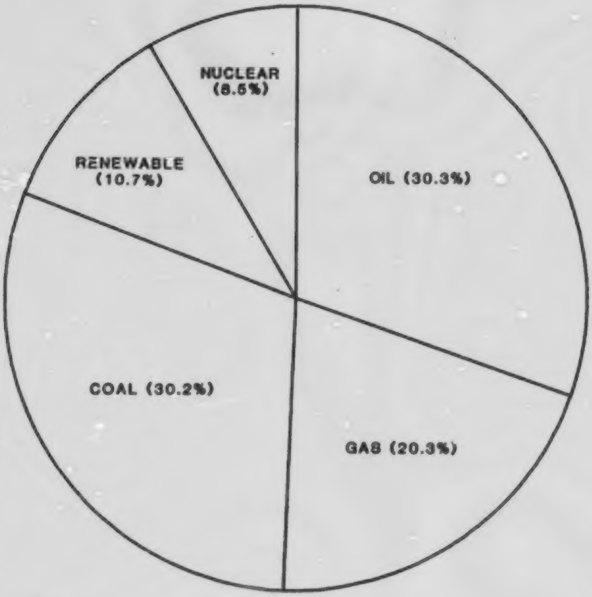
In summary, our recommendations move toward a greater balance among the fuel resources in the Fossil Energy research budget, seek consolidated management of closely related programs at a site that has established sound working relationships with the scientists, technologists, and producing states most concerned with these resources, and direct DOE to develop the implementation plans to establish a stable, effective program of basic research in oil, gas, and shale.

TOWARD A MORE BALANCED OIL, GAS, AND SHALE RESEARCH BUDGET

	Appropriated		1987	1987
	1985	1986	DOE Req.	Recomm.
Liquids Research				
Enhanced Oil Recovery				
-- Light and Heavy Oil	10.5	10.2	4.5	20.0
-- Tar Sands	1.2	1.3	0	2.0
Advanced Process Technology	5.4	5.5	1.8	6.0
S/T, Oil	17.1	17.0	6.3	28.0
Shale	14.6	12.1	3.6	12.0
S/T, Liquids	31.7	29.1	9.9	40.0
Unconventional Gas	10.1	8.5	5.3	10.0
Coop Venture Pool	0	0	12.5	0
TOTAL: Liquids and Gases	41.8	37.6	27.7	50.0

FIGURE 1

PROJECTED USAGE IN YEAR 2000

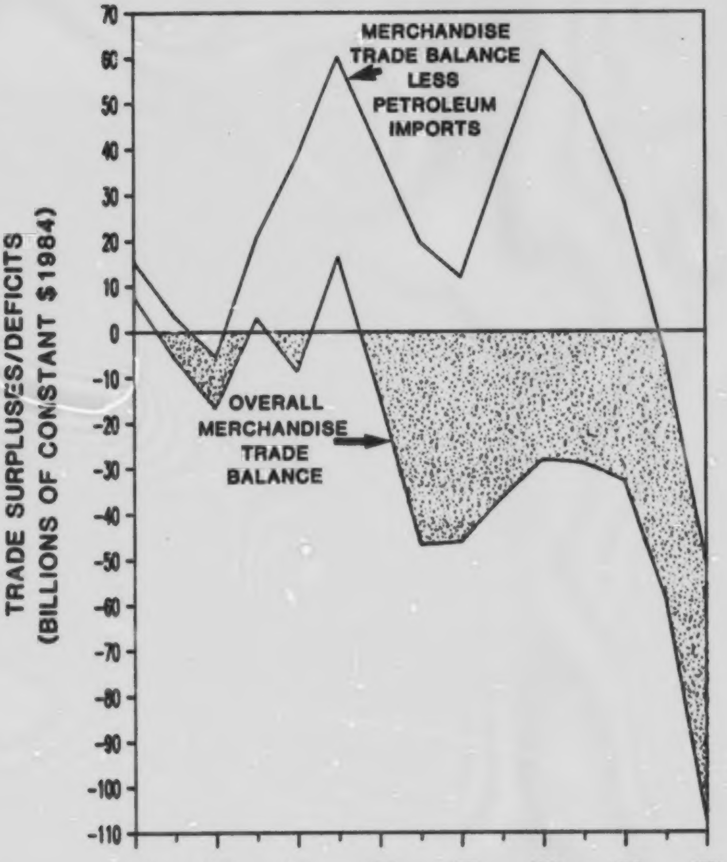


SOURCE: DOE/EIA, 1983.

BEST COPY AVAILABLE

FIGURE 2

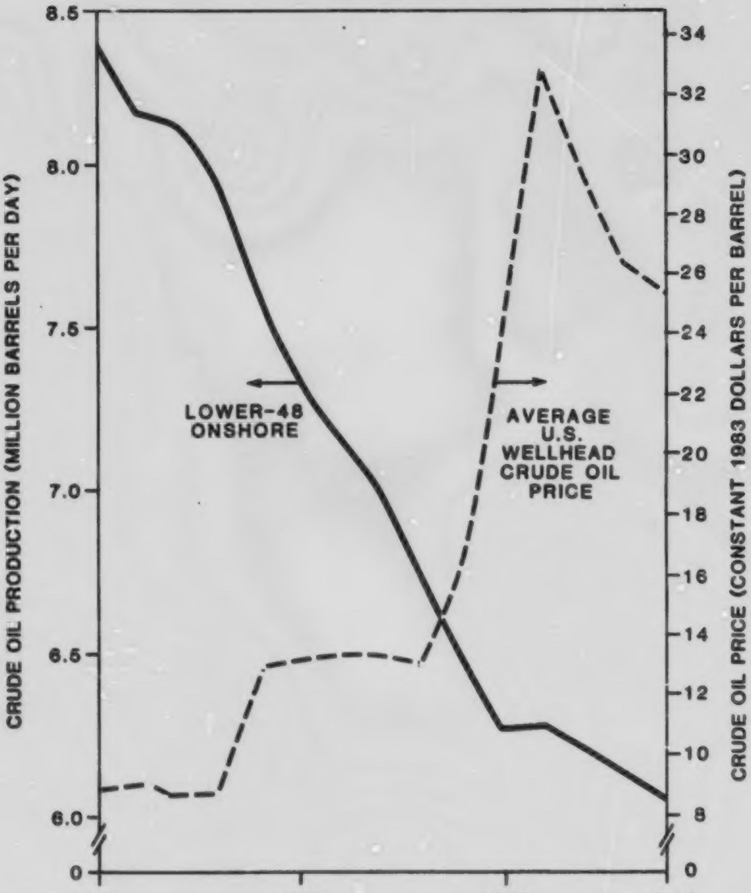
MERCHANDISE TRADE BALANCE WITH AND WITHOUT PETROLEUM IMPORTS



SOURCE: U.S. DEPARTMENT OF COMMERCE, 1985

FIGURE 3

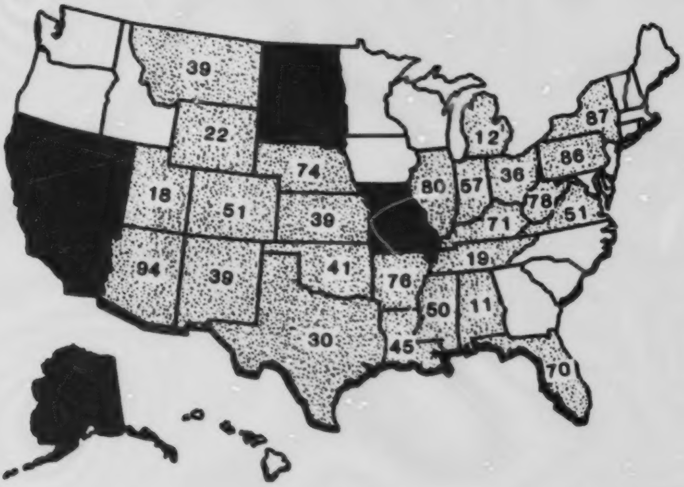
Lower-48 Production and Average U.S. Crude Oil Price



SOURCES: API/AGA/CPA, 1970-1979
EIA, 1980-1985

FIGURE 4

Production Decline in Oil Producing States
(% Decline from Peak Year to 1984)


39
22
74
18
51
39
94
39
41
30
76
45
50
11
80
57
12
36
87
86
78
51
71
19
70

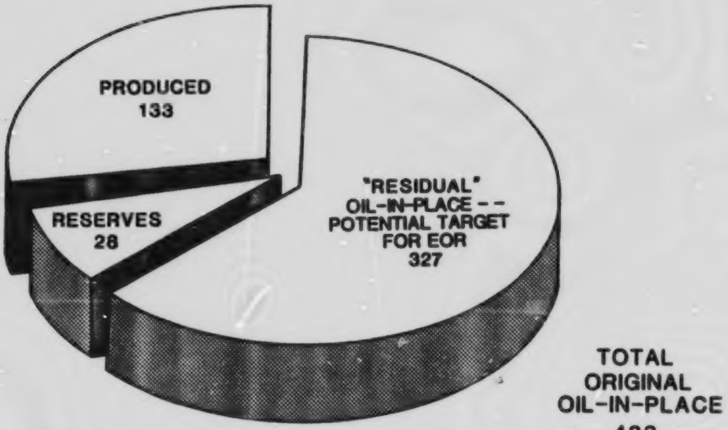
▨ Producer States With Declining Production From Peak Year
■ Producer States Not Yet In Production Decline

AVERAGE U.S. PRODUCTION DECLINE: 31%

SOURCES: API, 1984
EIA, 1985
IPAA, 1984

FIGURE 5

Domestic Resource Available for EOR
(Billions of Barrels)

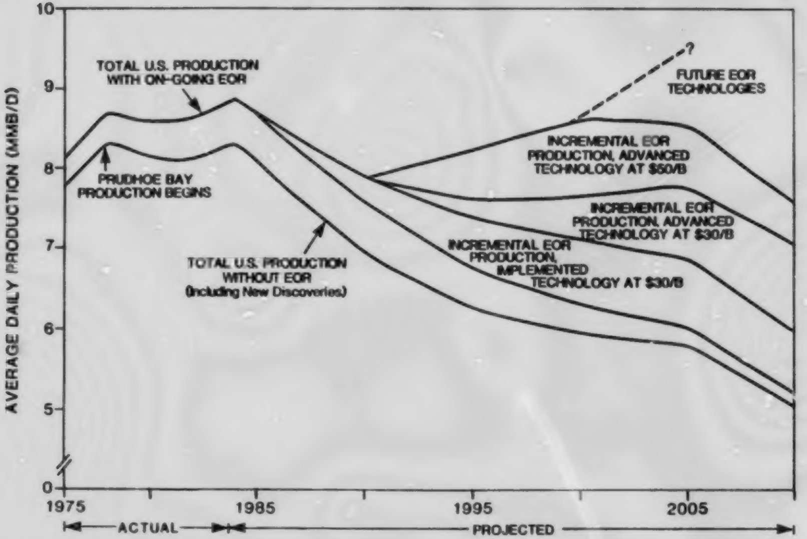


SOURCES: EIA, 1984
API/AGA/CPA, 1979

FIGURE 6

PROJECTED U.S. OIL PRODUCTION AND ESTIMATED CONTRIBUTION OF EOR

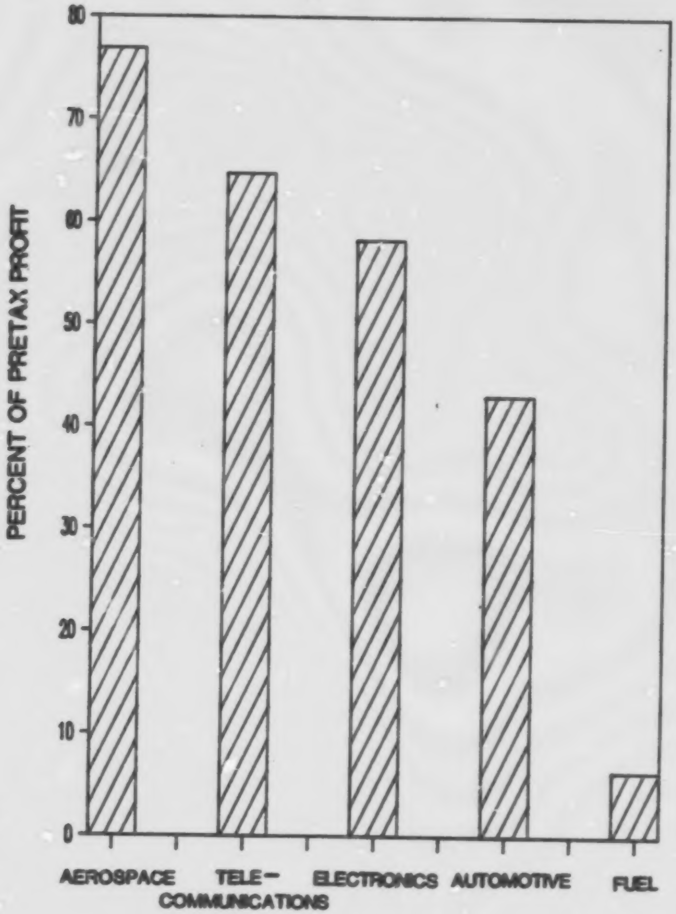
(NPC Implemented & Advanced Cases)



SOURCES: NPC, 1984
DOE, 1983
OIL AND GAS JOURNAL, 1984

256

FIGURE 7



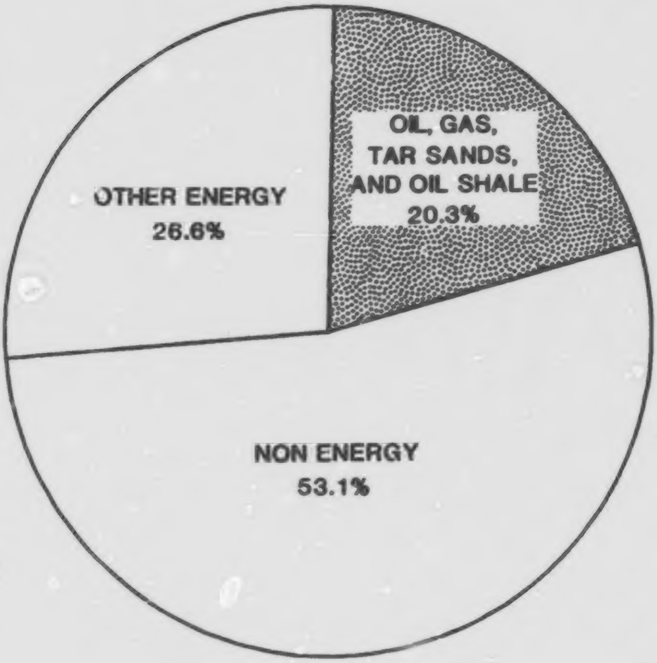
1984 INDUSTRY R&D EXPENDITURES
Percent of Pretax Profit

SOURCE: BUSINESS WEEK, 1985

FIGURE 8

1984 R&D EXPENDITURES

25 Major Energy Producers



SOURCE: DOE/EIA, 1985

FIGURE 9

ANALYSIS OF 1987 DOE BUDGET REQUEST

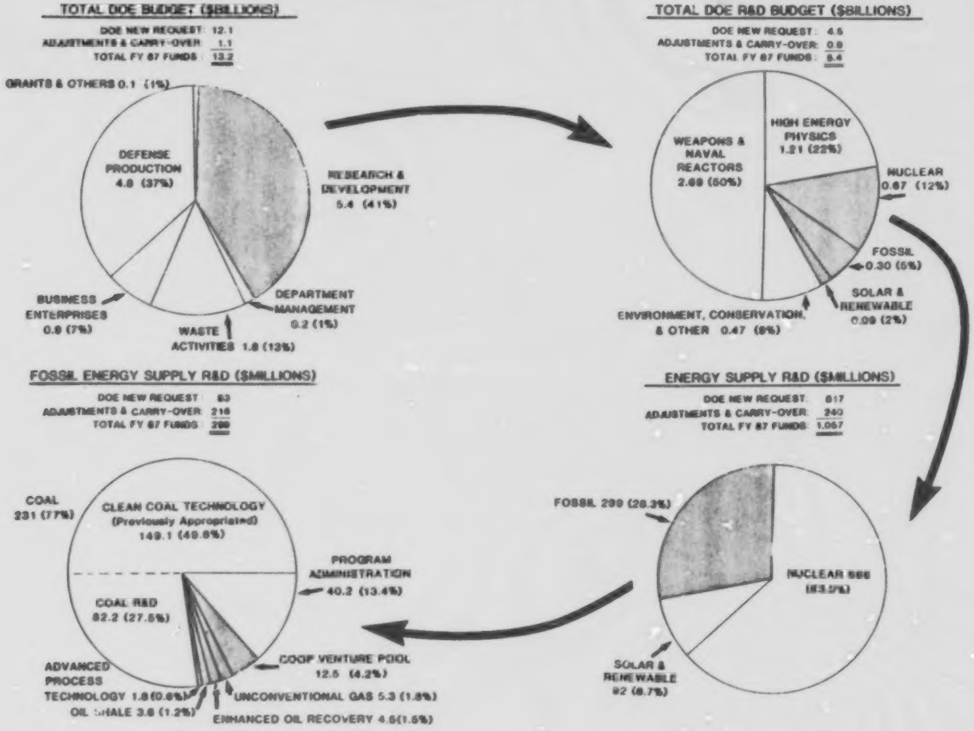


FIGURE 10

ESTIMATED OVERALL POTENTIAL OF NEW MEXICO OIL PRODUCTION AT $24.10/B UNDER THREE TAX INCENTIVES FOR CARBON DIOXIDE FLOODING

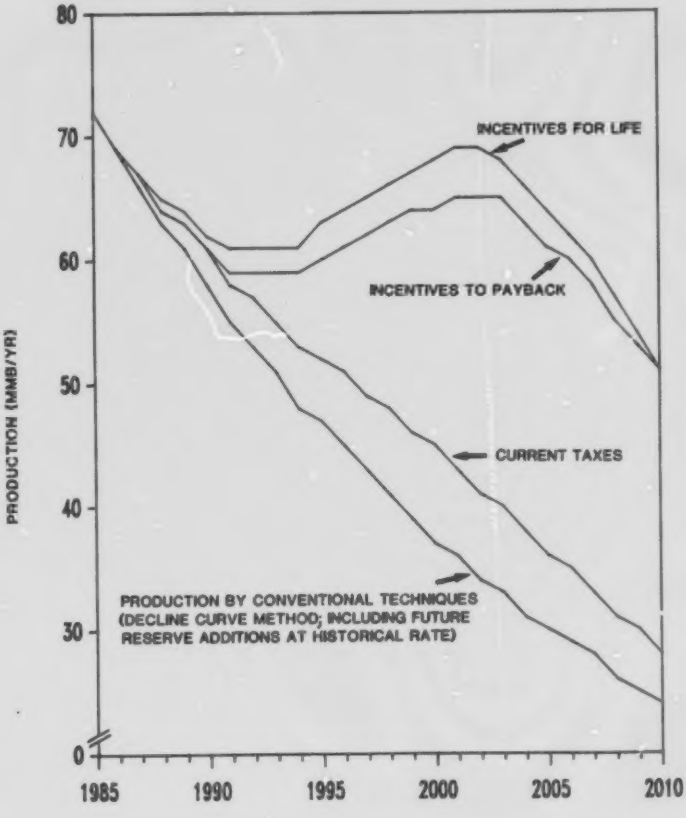
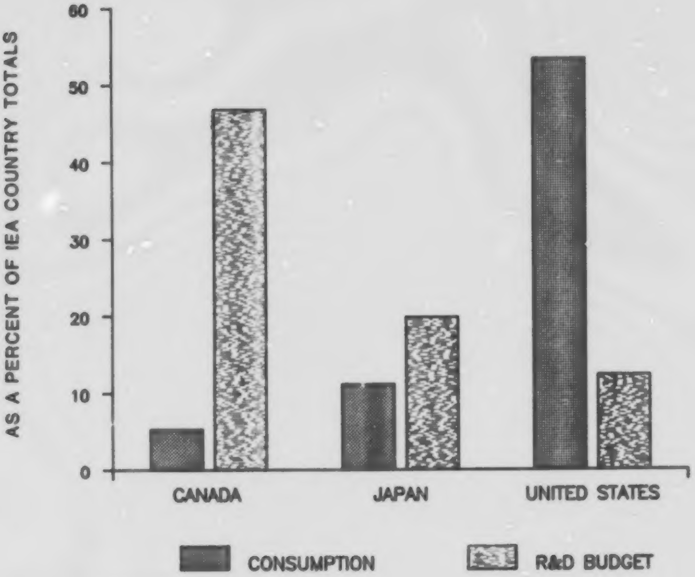


FIGURE 11

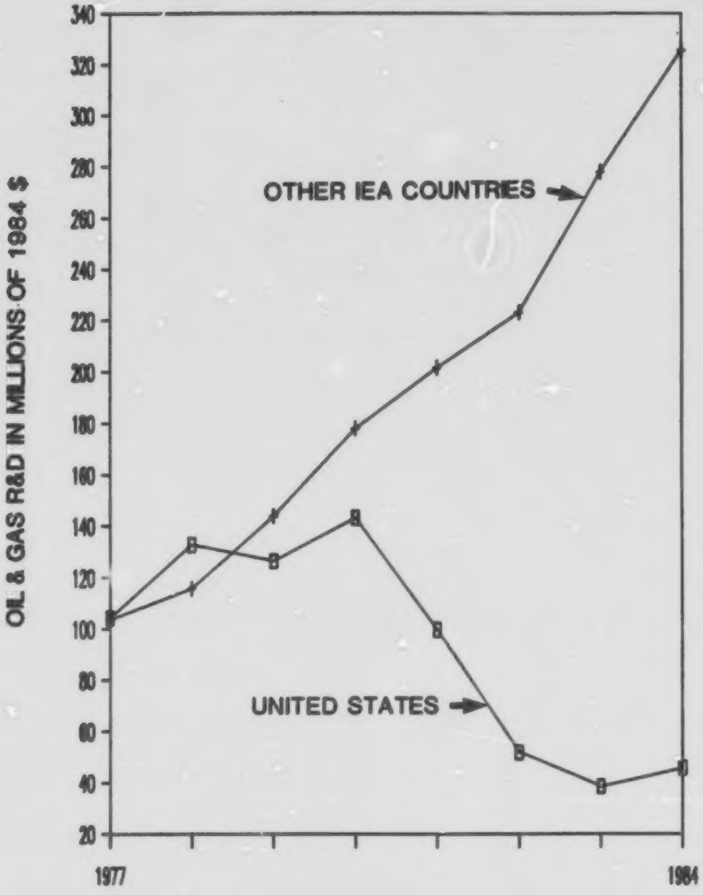
OIL AND GAS R&D EXPENDITURES VS. CONSUMPTION 1984



SOURCE: IEA, 1985

FIGURE 12

U.S. OIL AND GAS R&D VS. OTHER IEA COUNTRIES

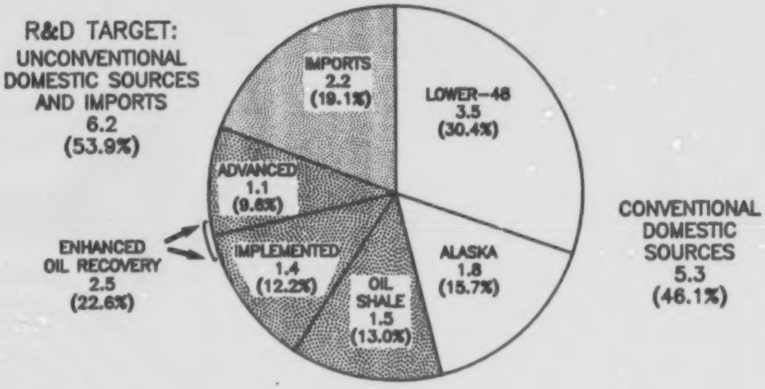


SOURCE: IEA, 1985

FIGURE 13

U.S. OIL SUPPLY IN YEAR 2010

EIA AND NPC ($50/BBL) PROJECTIONS



SOURCES: EIA, 1983
NPC, 1984

FIGURE 14

DISTRIBUTION OF FOSSIL ENERGY RESEARCH FUNDING

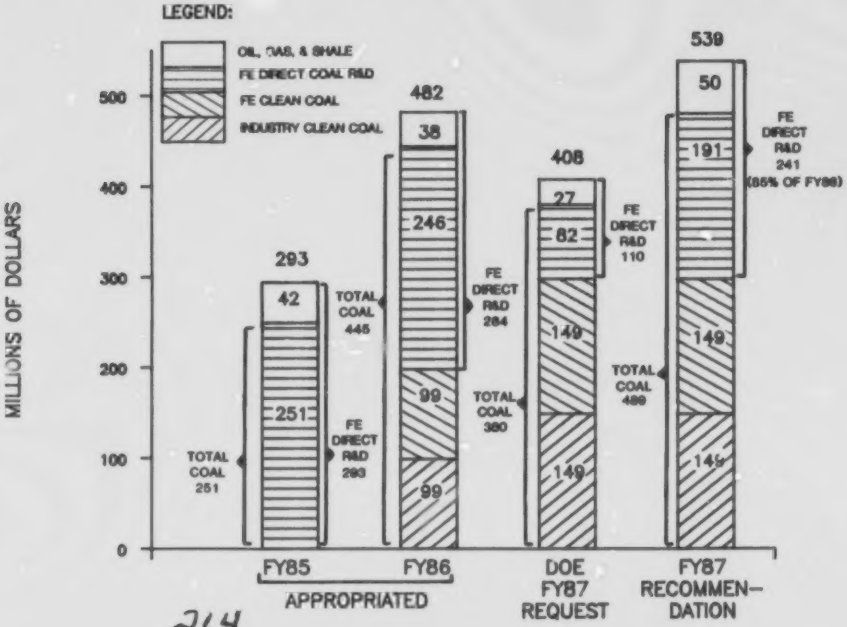


FIGURE 15

TOWARD A MORE BALANCED OIL, GAS, AND SHALE RESEARCH BUDGET

	Appropriated		1987	1987
	1985	1986	DOE Req.	Recomm.
Liquids Research				
Enhanced Oil Recovery				
-- Light and Heavy Oil	10.5	10.2	4.5	20.0
-- Tar Sands	1.2	1.3	0	2.0
Advanced Process Technology	5.4	5.5	1.8	6.0
S/T, Oil	17.1	17.0	6.3	28.0
Shale	14.6	12.1	3.6	12.0
S/T, Liquids	31.7	29.1	9.9	40.0
Unconventional Gas	10.1	8.5	5.3	10.0
Coop Venture Pool	0	0	12.5	0
TOTAL: Liquids and Gases	41.8	37.6	27.7	50.0

Mr. **Fuqua**. Thank you very much, Dr. Mankin.

Mr. Brown.

Mr. **Brown**. Mr. Chairman, for the record I am Dave Brown, president of the MHD Industrial Forum.

If you would, I would like my statement included for the record.

Mr. **Fuqua**. All right.

Mr. **Brown**. I would also like to submit the statements of Dr. Susan Wu, the administrator of the University of Tennessee Space Institute; Mr. Jack Sherick, president, MSE, Inc.; and Mr. Joe McElwain, chairman of the board of the MHD Development Corp.

Mr. **Fuqua**. We will make those part of the record.

I also would like to insert for the record, a statement by Congressman Hall, following the opening statement of Mr. Sensenbrenner.

Please proceed.

Mr. **Brown**. Thank you, Mr. Chairman, I will be very brief and just address a couple of points.

I would say that those statements set out for you, for the committee, an overall policy view from MHD community; and overview of the environmental promises of the technology, a status report on the technology to date. And a view to the future from the utility and private industry sector as to the afterlife of this program, when the DOE R&D is complete, relatively near term, we hope.

Overall I can say, Mr. Chairman, that we are pleased with the quality of the technical progress in the MHD program, but not its pace. DOE's constant foot dragging is sorely frustrating.

Industry worked hard with DOE in 1984 to some 6 months in the process to put together, at congressional direction, a program that can get to the light at the end of the tunnel.

We did that, that plan was submitted to the Congress, and the fiscal year 1986 continuing resolution mandates DOE to implement that multiyear program with increasingly significant costs shared from the private sector, which by the way, existed, has existed all the way along in this program.

Last Friday in the public meeting with DOE down at the Forrestal Building, industry informed DOE that the private sector is in a position, we believe, to provide the 10 percent required under the law, and that we will be sitting down with their Pittsburgh Energy Technology Office to validate that cost share and negotiate it, if you will, at the end of the year.

Industry does not see the cost share requirement as an inhibiting factor to continuation of the program. However, DOE headquarters may be, as it refuses to take all the procurement actions necessary to make that program move, and then in 5 years by prohibiting the procurement packages that are necessary to get on the street.

This costs, by the way, the Government and private sector a substantial amount of funds, let alone a major delay in the program. In addition, I need to comment on some remarks in my statement referencing an Italian MHD situation.

Mr. Chairman, the Italians went looking for a gas-fired power train from the Soviets, or a qualified power train from the United States, to retrofit an existing plant. Unfortunately, the Soviets' technologists are backed rather heavily by their Government, in our case DOE had indicated to the Italians that we lacked any interest in MHD. That did come up in the public meeting last Friday, and I am hopeful that Department of Energy will move to eliminate that negative attitude, and allow the private sector to go ahead and look at those programs.

What this does point out, though, Mr. Chairman, is that the world outside the United States is spending a substantial amount of time and money looking at the MHD technology and moving it forward. That light at the end of the tunnel is not that far away.

I think that Mr. Bauer's statement maybe points into some of the problems that we have and, if I might, point out the last comment on the MHD section of his statement. He says that other technologies can contribute more directly to the Nation's energy security with lower investment requirements, in a more timely manner, and a significantly more cost sharing.

Prior to the resolution of positions in the continuing resolution before Christmas, Congressman Regula had requested the Department to send an up overall cost share report throughout all of those technologies still in the fossil program. Quite frankly, MHD always has, and is now mandated by statute, to contribute three times more than the average cost share that is on the those books.

And I guess I just point that out for the record. That keeps popping up in the statements like this, and it kind of irritates the industrial sector, I think, as we look for a reliable partner in the Government to move ahead with this program, and especially one that has made the kind of technical progress this has.

In terms of a timely manner, I think the foreign experience in Italy, the Soviets 250 megawatt plant, and their present construction of a 500 megawatt plant, gas-fired but looking toward coal fired down the road, are all evidence that MHD is not that far away anymore, Mr. Chairman.

And I urge this committee to seriously consider the significant immediate impacts of the deferral action by this administration, and to look at continuing funding within the budget constraints that you obviously have to deal with in the programs for fiscal year 1987.

Thank you.

[The prepared statement of Dave Brown follows:]

MHD INDUSTRIAL FORUM

Suite 805, 1725 DeSales Street, N.W. Washington, D.C. 20036 (202) 775-8609

ADVISORY BOARD

Chairman
Kenneth A. Roe
Chairman and President
Burns & Roe, Inc.

Dr. F. W. Detra
Executive Vice President
Avco Everett
Research Laboratory, Inc.

Frank C. Fogarty
President and General Manager
Mountain States Energy, Inc.

Hon. George Fumich
Former Assistant Secretary
for Fossil Energy
U.S. Dept. of Energy

George W. Hardigg
Consultant and Former Vice President
Advanced Power Systems Division
Westinghouse Electric Corporation

William M. Irving
Vice President
Chas. T. Main, Inc.

Professor Arthur Kantrowitz
Dartmouth College

Joseph A. McElwain
Chairman and
Chief Executive Officer
Montana Power Company

Dr. David Murphree
Director, MHD Energy Center
Mississippi State University

Dr. Heinz G. Pfeiffer
Chairman, MHD Utility User's Group
Manager of Technology
and Energy Assessment
Pennsylvania Power and Light Company

Dr. Jerry D. Plunkett
President
Montana Energy Research
and Development Institute, Inc.

Dr. Richard J. Ross
Professor of Mechanical Engineering
Montana State University

Dr. John R. Sellars
Vice President and Manager
Energy Technology Division
Energy Development Group
TRW, Inc.

Wayne H. Traffas
Vice President and General Manager
Industrial and Energy Research Division
Gilbert Associates, Inc.

Dr. Y.C.L. Susan Wu
Administrator, Energy Conversion
Research and Development Program
Professor of Aerospace Engineering
University of Tennessee Space Institute

STATEMENT OF

MR. DAVE BROWN, PRESIDENT
MHD INDUSTRIAL FORUM
1725 DESALES STREET, N.W.
WASHINGTON, D.C. 20036

FOR THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
4 MARCH 1986

DIRECTORS

President
Dave Brown
MERDI

Vice President
Vincent J. Cicione, Jr.
Avco Corporation

Secretary/General Counsel
Zal E. Lipson
Wyatt, Saltzstein, Lipson & Hamberger

Treasurer
Dan O'Neil
TRW Inc.

Raymond W. Durante
Westinghouse Electric Corporation

Rick Edwards
Babcock & Wilcox

William Owens
Gilbert Associates

William H. Patterson
General Electric Company

Kenneth Roe
Burns & Roe, Inc.

BEST COPY AVAILABLE

STATEMENT OF
DAVE BROWN, PRESIDENT
MHD INDUSTRIAL FORUM
4 MARCH 1986

Mr. Chairman and Members of the Subcommittee, I appreciate the opportunity to appear before you today.

With the passage of the FY'86 Continuing Resolution, DOE is statutorily mandated to carry out its multi-year redirected MHD development program. We in the MHD community felt renewed optimism and have worked hard to meet the ten percent cost sharing requirement in FY'86.

Unfortunately, I am here to tell you we are totally frustrated by the Department of Energy's constant foot dragging and are discouraged about the nation's future ability to maintain its leadership in energy-related high technology development.

During 1984, the MHD community worked long and hard with dedicated DOE professionals, led by former Assistant Secretary William Vaughan, to work out an MHD development program that made programatic, technical and budgetary sense which would lead to the retrofit phase in five years. The plan was submitted to Congress in June 1984.

As both Congressmen Murtha and Regula can tell you, this year the coal combustor was completed, installed in the CDIF, and testing begun. We are pleased with the quality of technical progress within the overall MHD program but unfortunately not its pace. We have worked hard the last two months putting together a package to meet the cost sharing requirements of the FY'86 Continuing Resolution. We will have, if DOE conducts a program, the required cost share, much of it in cash this year and hopefully all in cash in FY'87. I must also tell you that many industrial participants helped develop this package with reservations about the reliability of DOE and OMB as business partners. Regrettably, DOE has proven the skeptics right.

In spite of the FY'86 Continuing Resolution's MHD appropriation and its mandate that DOE "implement the multi-year plan for MHD," DOE and OMB have decided to ignore the law and terminate all MHD development once again in FY'87 and in FY'86 with use of a deferral action. I would remind the Committee that we have to win every time while they only have to win once. A program stoppage for any length of time will kill this program.

DOE is ignoring the FY'86 Continuing Resolution statutory direction to run an MHD program and so far has refused its Pittsburg Energy Technology Center permission to initiate the procurements needed to carry out the redirected multi-year program.

At an international conference held in Rome in early January, the Italians announced plans to retrofit an existing power plant with an MHD power train which will be purchased from the Soviets or United States industry. Soviet MHD technologists were strongly supported by their government in their effort to convince the Italians of the superiority of the USSR natural gas burning MHD power train.

Unfortunately, American efforts to sell our coal burning system to the Italians was undermined, perhaps irrevocably, by a DOE spokesman who announced that the U.S. Government had no interest in MHD or the Italian MHD effort even though the United States has an international agreement with Italy which includes MHD development.

Sadly, DOE's practices and policies provide little confidence in its commitment to a strong national energy policy which, as Congressman Regula told the Clean Coal Conference in a very thought-stimulating speech last week, "is vital to our ability to compete in the next decades and century". MHD is a high technology solution to efficient use of this nation's abundant coal reserves for growing electric capacity with little environmental impact.

While the deficit is a serious matter, it is one to be addressed by the Congress and the President as provided in the Constitution and not through arbitrary, unilateral action by OMB, DOE or any other branch of the executive department.

I hope the Congress will insist that deferrals not be used as a back door approach to line item vetoes. I ask you to consider recommending an authorization for FY'87 at least equal to this years $29M budget to carry out the multi-year MHD Program as a forceful reminder to DOE and OMB that the FY'86 Continuing Resolution is the law of the land.

Thank you again on behalf of all my colleagues in industry, research and development institutions, and colleges and universities for your support of MHD and a strong national coal energy policy.

Mr. **Fuqua**. Thank you very much.

How much, Mr. Brown, do you think the minimum Federal funding would be required, as well as industry's share for a total cost, to complete the long-term bottoming cycles, and also long-term topping cycles?

Mr. **Brown**. You are talking about over time?

Mr. **Fuqua**. Yes.

Mr. **Brown**. I guess I had better supply that for the record, Mr. Chairman. I can do that.

Mr. **Fuqua**. That would be very helpful, if we could get that.

Mr. **Brown**. The numbers exist, I am just not recalling them as well as I should.

Mr. **Fuqua**. That is all right, I understand.

Dr. Mankin, there are those who claim that a weak demand for crude oil kind of shifts the emphasis to applied research on enhanced oil recovery, and it is also claimed that chemical and biological processes are seen as probably the most promising future approaches.

Could you comment on that?

Dr. **Mankin**. Yes, sir. Both the biological process that has been proposed in the area of enhanced oil recovery is clearly in a condition of basic research. It is being conducted at several universities at the present time. There is some work going on within industry, although quite limited.

The basic problem that we have in trying to apply any enhanced oil recovery technology is, first, we found as a result of the experience in the middle 1970's, that we didn't know as much about petroleum reserviors as we thought we did, and we didn't know as much about fluid rock interaction as we thought we did. The net effect of that was the Federal Government participated in a massive field test program, using some technologies well before their time.

The net effect of that was that most of those field test programs were failures, unfortunately, not enough basic information was collected to determine why they were failures. There were a few successes. And we don't know exactly why they succeeded.

We do know today that the reservoirs are a much more complex beast than we thought it was when we first began working in that area.

Before we can apply effectively biological techniques or chemical techniques in flooding for improving recovery of existing fields and reserviors, we are going to have to understand a great deal more about the habitat of that oil, the fluid-rock interaction characteristics, in order to maximize the recovery from some very complicated rocks in the subsurface.

There has been a great deal of work done. There has been a great deal of progress made.

I witnessed the very successful effort of steam flooding in Kern River in California, and the beginning efforts of CO_2 in west Texas. Those are only starts, and those are only fractional amounts of the potential.

We have a very long way to go. And I think we are in the process of abandoning the program just at the time when we will be getting some results if we stay with it.

Mr. **Fuqua**. What would be the cost of restoring wells, if we just let the industry continue to decline?

Dr. **Mankin**. Well, sir, one of the common comments that you hear is that, well, let's use up all the oil from overseas first, and then we will use ours up later. But let me comment on the State of Oklahoma.

At the present time in Oklahoma there are about 100,000 producing oil wells. If you had the drilling rigs, and if you had the crews, and if you had the pipe, and if you didn't have the escalation in costs that are associated that we experienced in the drilling boom of early 1980's, the average cost of drilling those wells, would be about $400,000, drilling and completing those wells would be about $400,000 each.

That would mean that you are spending about $40 billion just to put the industry back to where it is today, if you try to do it at some point in the future.

Mr. **Fuqua**. How about restoring those wells?

Dr. **Mankin**. Well, sir, once you have abandoned a well, regulations require that the well be plugged. You put a concrete plug in the bottom and a concrete plug at the top, and the cost of drilling out those plugs and restoring that well would be more than drilling a new one.

There are 675,000 producing oil wells in the United States. That number of 400,000 is an approximate number that would be appropriate——

Mr. **Fuqua**. What was that number?

Dr. **Mankin**. There are 675,000 producing oil wells in the United States, and if you want to multiply that by 400,000, you will get a picture of about what it would cost to restore the present petroleum industry in terms of wells. That does not include the surface facilities; it doesn't include all of separater tanks, the pipeline systems, and all the other facilities that are needed to maintain that activity.

Mr. **Fuqua**. Dr. Holland, what effort has been directed to the production of gases, other than liquids from the eastern shale?

Dr. **Holland**. Well they are certainly are in the unconventional gas program. There has been an effort to produce gas from the Devonian shales. That is really in the upper Appalachians, Ohio, Pennsylvania, New York, West Virginia, and Kentucky primarily.

But there has been relatively little effort to produce liquids from the eastern shale. If you would look at the total national oil shale program, for about every $20 that has been spent on western shale, there has been a dollar spent on eastern shale. So there is an imbalance.

Mr. **Fuqua**. Gentlemen, I want to thank you. We may have some questions we want to submit to you further for amplification, with your permission.

[Additional questions and answers for the record follow:]

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Department of Energy (DOE)
FY 1987 Authorization Request for
Fossil Energy

March 4, 1986

Additional Questions for the Record

Dr. J. Read Holland

1. In 1982, the Oak Ridge National Laboratory published a report on resource and technology for the recovery of hydrocarbons and minerals from Eastern oil shale. In your knowledge, have the several Eastern States followed up on that study?
2. We have been advised that the 40 kilowatt fuel cell located on the University of Alabama campus has completed its operation and has been removed from the site. Please describe that program, its successes, and its failures. What economic application for this size unit do you see in your area?
3. It is anticipated that the out-years will see continuation of significant cuts in the R&D budgets. Are there any other fossil energy programs which can be combined with the Oil Shale program to maintain continuity, a meaningful level of effort, and a steady stream of data into an information base?

SCHOOL OF MINES AND ENERGY DEVELOPMENT

The University of Alabama Box 6282 University, Alabama 35486 Tel. 205/348-4520 ACTS 243-4520

March 25, 1986

The Honorable Don Fuqua
Chairman, Subcommittee on Energy
Development and Applications
U. S. House of Representatives
Suite 2321 Rayburn House Office Building
Washington, D. C. 20515

Dear Congressman Fuqua:

Your letter of March 5 did not arrive in my office until March 17 because the University closes the second week of March for spring break. Hence the delay in responding to your questions. I will answer the questions in the order presented in your letter.

1. To our knowledge there has been very little, if any, work on the coupled recovery of hydrocarbons and minerals from Eastern oil shale. We had done some work in this area prior to the ORNL Report written late in 1981 by I. Spiewak, T. M. Filliam and M. D. Silverman, and we have had a continuing interest in the subject. Our efforts subsequent to 1981 have been primarily limited to following any published literature on the subject. We have found no significant, newly-published literature in this time.

2. The 40 kilowatt fuel cell power plant project at the University of Alabama campus was a joint project with Southern Company Services, the research arm of Southern Company, the University of Alabama, and Kaneb Services. Kaneb Services is a Houston-based energy company which has interests in oil exploration, gas pipeline services, and coalbed methane development. Southern Company is the major holding company for Alabama Power Company and other power companies in adjacent states. The fuel cell power plant was located on the university campus because of the availability of the student recreation building and its proximity to a coalbed methane producing site.

The University of Alabama has two coalbed methane research wells located in the eastern part of its campus near the Student Recreation Building. These wells were the source for coalbed methane which was used experimentally to power the fuel cell power plant along with commercial natural gas. The system was set up so the fuel cell could operate either with coalbed methane or with commercial natural gas. The commercial gas was installed primarily as start-up and back-up energy for the power plant, but, in fact, the power plant operated for longer periods of time on commercial gas than it did on coalbed methane. Some difficulties were experienced with methane production that were completely independent of the fuel cell.

The student recreation building was favorable for the application of a 40 kilowatt experimental fuel cell power plant because its peak load for electricity was around 80 kilowatts. There were periods when 40 kilowatts was adequate to meet its operating load and there were also periods when the building demand was below 40 kilowatts which gave the research team an opportunity to gain experience with feeding power back into the Alabama Power Company grid. In addition, the recreation center required heat for the domestic hot water system which was supplied as a part of the cooling system for the fuel cell power plant, which allowed it to operate in a co-generation mode and increased its total energy efficiency to around 85 per cent.

The project began in 1984 and was conducted throughout 1985 terminating in late January 1986. Currently the collected data and results are being analyzed for final report generation which should occur in mid-1986. The experience with the power plant proved that fuel cells are practical for a number of applications, particularly where the heat from the cell can be utilized along with the power generated. The 40 kilowatt size is not practical for most applications and our current understanding is that International Fuel Cells, a subsidiary of United Technologies Corporation, will be producing a 200 kilowatt model for the gas utilities. The 40 kilowatt size was produced strictly as a research unit to evaluate the practical application of fuel cells for isolated power generation.

A 200 kilowatt unit is large enough to handle many applications with small businesses or with single major buildings such a classroom or office building. Electrical power companies probably will not be interested in a fuel cell smaller than one megawatt. Transportation may also be a factor in marketing fuel cell power plants. A 200 kilowatt plant is probably the largest size unit which can be transported over the nation's highways by a single truck. This is about the smallest size practical for many large building applications.

The project at the University of Alabama demonstrated that the power plants are practical for many applications where a small clean source of electricity is required. There were some problems with the 40 kilowatt research unit because of its prototypic nature. The unit was designed to fit through a standard double door to accommodate applications requiring the system to be placed in-doors. Consequently, the internal components were packed very tightly within the machine which made it difficult to maintain and caused some problems with respect to heat dissipation. Commercial units would not be so densely assembled.

3. In my opinion, the recommendation made by Dr. Charles Mankin, State Geologist, Oklahoma Geological Survey, to place all the liquid and gaseous hydrocarbons fuels into a combined program is a logical move. Technical direction and planning for this program should improve significantly and the priorities for this area should be more effectively established both within and outside the Department of Energy. I urge that a viable fossil energy research program be maintained because of the vital link between the assured availability of energy sources at reasonable costs and economic health of the nation. A well conceived and well executed plan of research for fossil is essential to maintaining this assured availability of energy sources at reasonable costs. In this regard, this plan should emphasize research, both basic and applied, with an appropriate level of technological development on the part of the Department of Energy. Demonstration projects are best left to the industrial sector with limited funding assistance from the Department of Energy.

Sincerely,

J. Read Holland

J. Read Holland
Director

JRH:rkm

OKLAHOMA
GEOLOGICAL SURVEY
Charles J. Mankin, Director

March 15, 1986

RECEIVE
MAR 1 9 1986
COMMITTEE ON SCIEN
AND TECHNOLOGY

The Honorable Don Fuqua, Chairman
U.S. House of Representatives Committee
on Science and Technology
Suite 2321, Rayburn House Office Building
Washington, D.C. 20515

Dear Chairman Fuqua:

I received your communication of March 5 asking that I respond to two additional questions in connection with my testimony before the Subcommittee on Energy Development and Applications on March 4, 1986. Enclosed is my response to those questions.

I appreciated the opportunity of appearing before your Subcommittee in order to present some information and recommendations relative to the Department of Energy's fossil fuel budget for the coming fiscal year. Should you or your colleagues have any additional questions or desire further clarification on these matters, please do not hesitate to contact me.

Sincerely yours,

Charles J. Mankin

Charles J. Mankin
Director

CJM:bb

Enclosure

THE UNIVERSITY OF OKLAHOMA / 830 VAN VLEET OVAL, ROOM 163 / NORMAN, OKLAHOMA 73019 / PHONE (405) 325-3031

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

Hearing on Department of Energy (DOE)
FY 1987 Authorization Request for
Fossil Energy

March 4, 1986

Additional Questions for the Record

Dr. Charles J. Mankin

1. What benefits does your state geology program derive from the National Institute for Petroleum and Energy Research?

We have no direct involvement nor do we receive any direct benefits from the National Institute for Petroleum and Energy Research (NIPER). However, the research result produced by this organization and the basic data files maintained by them are valuable in evaluating the enhanced oil recovery potential for our State. The University of Oklahoma has received some funding from the Bartlesville Project Office (DOE) for enhanced oil recovery research. That of course is different from NIPER which is the DOE laboratory being operated by the Illinois Institute of Technology.

2. Do you know of untried and unproven enhanced oil recovery processes which might be considered by competing companies to be sufficiently attractive that they would provide funds along with the Federal Government to be planned and demonstrated?

To the best of my knowledge, there is no untested enhanced oil recovery process that is sufficiently advanced to be considered for a full-scale field test. Work underway in microbial processes may be only a year or so away from a field test assuming funding is available to continue the basic bench-scale work. Variations of previously tested processes may be somewhat closer but the needed experimental design of a full-scale field test has not been initiated. The development of an experimental design would require a great deal of time to ensure that any field test would yield the maximum amount of valuable data.

MHD INDUSTRIAL FORUM
Suite 805, 1725 DeSales Street, N.W. Washington, D.C. 20036 (202) 775 8609

April 1, 1986

ADVISORY BOARD

Chairman
Kenneth A. Roe
Chairman and President
Burns & Roe, Inc

Dr R.W. Detra
Executive Vice President
Avco Everett
Research Laboratory, Inc

Frank C. Fogarty
President and General Manager
Mountain States Energy, Inc

Hon. George Fumich
Former Assistant Secretary
for Fossil Energy
U.S. Dept. of Energy

George W. Hardigg
Consultant and Former Vice President
Advanced Power Systems Division
Westinghouse Electric Corporation

William M. Irving
Vice President
Chas. T. Main, Inc

Professor Arthur Kantrowitz
Dartmouth College

Joseph A. McElwain
Chairman and
Chief Executive Officer
Montana Power Company

Dr David Murphree
Director, MHD Energy Center
Mississippi State University

Dr Heinz G. Pfeiffer
Chairman, MHD Utility User's Group
Manager of Technology
and Energy Assessment
Pennsylvania Power and Light Company

Dr Jerry D. Plunkett
President
Montana Energy Research
and Development Institute Inc

Dr Richard J. Rosa
Professor of Mechanical Engineering
Montana State University

Dr John R. Sellars
Vice President and Manager
Energy Technology Division
Energy Development Group
TRW Inc

Wayne H. Trallas
Vice President and General Manager
Industrial and Energy Research Division
Gilbert Associates, Inc

Dr Y.C.L. Susan Wu
Administrator, Energy Conversion
Research and Development Program
Professor of Aerospace Engineering
University of Tennessee Space Institute

The Honorable Don Fuqua
Chairman
Subcommittee on Energy Development
and Applications
Committee on Science and Technology
B-374 Rayburn HOB
Washington, D.C. 20515

Dear Chairman Fuqua:

Please find attached my responses to the three questions you requested an answer to following my March 4 testimony before your subcommittee. If they are not satisfactory in any way, please do not hesitate to let me know.

I apologize for the late response to your request. Unfortunately, I have been in Montana for a Special Session of the Montana Legislature and did not receive your letter as quickly as I normally would. I hope my slow response will not inconvenience you in any way.

Thank you for the opportunity to testify and for your continuing support of MHD technology development.

Sincerely,

Dave Brown

Dave Brown
President

DIRECTORS

President
Dave Brown
MERDI

Vice President
Vincent J. Coates, Jr
Avco Corporation

Secretary/General Counsel
Zel E. Lipsen
Wyatt, Saltzstein, Lipsen & Hemberger

Treasurer
Don O'Neil
TRW Inc

Raymond W. Durante
Westinghouse Electric Corporation

Rick Edwards
Babcock & Wilcox

William Owens
Gilbert Associates

William H. Patterson
General Electric Company

Randall Roe
Burns & Roe, Inc

BEST COPY AVAILABLE

RESPONSE TO QUESTIONS FROM CHAIRMAN FUGUA, SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS, HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY, MARCH 4, 1986 HEARING

Question 1. It is claimed that the MHD process requires long-term bottoming cycle runs, long-term topping cycle runs, and seed regeneration process characterization to complete the data base for the overall program. What is the minimum federal funding necessary to accomplish those goals, and to what extent will industry share in the total cost?

The testing described in the question is the bulk of the DOE June, 1984, MHD program as sent to Congress. In addition to the testing described, a retrofit conceptual design is also required. The June, 1984 program was jointly developed at Congressional direction by DOE and industry. Its basis is to test and evaluate MHD components and systems for reliability and duration testing to meet utility industry requirements.

The minimum federal funding as described in the joint DOE/industry program plan was $150-160 million over five years. That figure is still reasonable. However, it should be pointed out that while the program implementation was to begin in FY 1985, DOE's constant foot dragging through failure to issue necessary procurement actions, constant proposed reductions in funding requests, and continual deferral requests has impacted the pace of the program.

Private industry is prepared to share the costs of the program in accordance with the cost sharing requirements set forth in the statutory and report language of the FY 1986 Continuing Resolution. Negotiations on validation of and what counts toward cost share are presently underway with DOE's Pittsburg Energy Technology Center.

The private sector is also on record before the Congress and at DOE as being willing to cost share fifty percent of the retrofit phase once the redirected multiyear DOE MHD program is completed successfully.

Question 2. Will the installation of a superconducting magnet at the Butte facility be necessary to characterize the topping cycle?

While the installation of a superconducting magnet at the Butte facility would provide hands on experience with a superconducting magnet in an MHD environment, it is not necessary for accomplishing required engineering development at the CDIF nor for characterizing the topping cycle.

There is no physical difference between a magnetic field generated by a superconducting magnet or an iron core magnet. Superconducting magnet technology is well understood and these magnets have been in use for nearly fifteen years. The DOE/industry discussions leading to the June, 1984, program plan lists superconducting magnets as an off-the-shelf item. The purpose of a superconducting magnet in an MHD power system is to increase operating efficiencies. Specifically, iron core magnets take approximately half of the gross power generated while the superconducting magnets use only a small fraction.

Question 3. What location is the least expensive to characterize the seed regeneration process?

As part of its planning to implement the June, 1984 DOE redirected MHD development program, the DOE Pittsburg Energy Technology Center has prepared a competitive procurement to select an industrial firm to design, build and operate a seed regeneration test system and to select an appropriate site.

A competitive industry procurement is considered the most effective method for ensuring the lowest overall cost to the federal government. Since several industrial companies desire to bid this procurement, this process seems to be the best procedure to follow.

It should be pointed out that this procurement as well as procurements in the combustor and channel areas needed to advance the redirected MHD program have been unduly held up by OMB and the Acting Assistant Secretary for Fossil Energy for several months.

Mr. **Fuqua**. We thank you very much for being here today. I am sorry to keep you waiting so late.

Dr. **Holland**. Thank you, Mr. Chairman.

Dr. **Mankin**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you very much.

[Whereupon at 1:20 p.m., the hearing adjourned.]

BLANK PAGE

THE FUEL CELL
USERS GROUP
OF THE ELECTRIC UTILITY INDUSTRY, Inc

1101 Connecticut Avenue, NW
Suite 700
Washington, DC 20036
202/457-0868

BOARD OF DIRECTORS

Lelan F. Sillin, Jr
Northeast Utilities Service Company
Chairman

William F. Matson
President
Allegheny Electric Cooperative, Inc
Vice Chairman

Bob Bergland
Executive Vice President and General Manager
National Rural Electric Cooperative Association

James E. Bruce
Chairman and CEO
Idaho Power Company

Walter E. Canney
Administrator
Lincoln Electric System

John M. Endries
Senior Vice President
Niagara Mohawk Power Corporation

Richard M. Freeman
Director
Tennessee Valley Authority

Toby Gilsig
Vice President, Research & Director, IREQ
Hydro Quebec

William R. Gould
Southern California Edison Company

William B. Harrison
Senior Vice President
Southern Company Services, Inc

Arthur Hauspurg
Chairman, President, & CEO
Consolidated Edison Company of New York, Inc

William McCollam, Jr
President
Edison Electric Institute

Alex Radin
Executive Director
American Public Power Association

Harold W. Sonn
Chairman, President, & CEO
Public Service Electric & Gas Company

William R. Vogelsang
President & CEO
Central Illinois Gas Company

Robert A. Bell
Vice President
Consolidated Edison Company of New York, Inc
President

Robert W. Fri
Advisor to the Board
Jeff[illegible] A. Serfass
Ex[illegible]tive Director

March 14, 1986

Mr. William Harvey
Staff Director
Subcommittee on Energy Development
& Applications
Rayburn House Office Building
Room B-374
Washington, DC 20515

Dear Mr. Harvey:

Enclosed please find a copy of the written testimony of Mr. Stephen A. Mallard of Public Service Electric and Gas Company on behalf of the Fuel Cell Users Group of the Electric Utility Industry, Inc. We ask that it be included as a part of the record of the Subcommittee as it considers the DOE fuel cell budget for FY 87 and the pending deferral of FY 86 funds.

The Fuel Cell Users group wishes to make the following points which we believe are important in your upcoming considerations:

1. The Fuel Cell Users Group supports the commercialization programs of both Westinghouse Electric Corporation and International Fuel Cell Corporation (IFC).

2. The utility industry is now seriously considering the IFC commercial offering and, by year end, many utilities will likely have begun negotiations with IFC for the purchase of a fuel cell power plant. Separately, utilities are considering financial support of Westinghouse's 7-1/2 MW program.

3. Although the technology with today's costs and heat rate will be economical in certain locations and in specific applications, its current use is limited to situations with environmental and/or siting problems. Lower capital costs

and improved efficiency are still required to ensure that widespread application can be obtained.

4. The government's continued support of applied research and development is vital for continued technology break-throughs that will yield the improved costs and efficiency.

5. The private sector will make its purchasing and investment commitments only if it understands that these technological improvements are forthcoming.

6. The Fuel Cell Users Group of the Electric Utility Industry, Inc. supports funding of at least $10 million for the 7 1/2 MW and 11 MW phosphoric acid programs to ensure that the necessary technology development efforts can proceed in step with the private sector's commercialization commitments.

Thank you for the opportunity to comment on this most important issue. We would be happy to present additional information on the utility industry's perspective on fuel cell development should this be required.

Sincerely,

Jeffrey A Serfass

Jeffrey A. Serfass
Executive Director

JAS/rcp
enc.

STATEMENT ON
FUEL CELL RESEARCH, DEVELOPMENT AND COMMERCIALIZATION AND THE FEDERAL BUDGET FOR PHOSPHORIC ACID FUEL CELL TECHNOLOGY

Presented to the
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
to the
COMMITTEE ON SCIENCE AND TECHNOLOGY

Stephen A. Mallard
Senior Vice President
Public Service Electric & Gas Company
Newark, New Jersey
on behalf of the
FUEL CELL USERS GROUP OF THE ELECTRIC UTILITY INDUSTRY, INC.
March 14, 1986

Mr. Chairman, I am Stephen A. Mallard, Senior Vice President for Public Service Electric & Gas Company of Newark, New Jersey. I would like to discuss the status of fuel cell technology development and the opportunity for its commercialization because my company has been supporting the development of this technology for nearly 20 years. Our company was one of nine electric utility who joined with United Technologies Corporation to develop multimegawatt fuel cell power plants and test a one megawatt demonstration unit in the mid-1970s. Our company has continued to support the development of this technology, with both financial and manpower resources, and is considering being one of the first purchasers of the commercial power plants now being developed.

I am also testifying on behalf of the Fuel Cell Users Group of the Electric Utility Industry, Inc. The Fuel Cell Users Group is an organization of 55 electric utilities including the national trade associations of the electric power industry: The American Public Power Association, National Rural Electric Cooperative Association, and the Edison Electric Institute. The Users Group was established in 1980 to assist, promote and accelerate the development and electric utility application of phosphoric acid fuel cell technology.[1]

The Fuel Cell Users Group and my remarks are focused solely on the development and application of phosphoric acid, multi-megawatt fuel cell technology. Our company has also been an active participant in the gas industry's on-site 40 kW program including the testing of two of the 40+ units being operated throughout the country. We also have an interest in the long term potential of molten carbonate and solid oxide technologies. It is the multi-megawatt phosphoric acid technology, however, that offers to electric utilities the early promise of a clean, modular, efficient electrochemical generation technology for siting and operation in urban locations and remote applications as well.

---

[1] The Fuel Cell Users Group of the Electric Utility Industry, Inc., is a five-year old organization with a membership of 55 utilities (and 10 associate members) spanning the privately, publicly, and cooperatively owned electric utility industry. A list of the membership is included as Attachment 1. Cumulatively, the members of the Users Group represent about 40 percent of the U.S. generating capacity. The Group is united in the interest of encouraging and supporting research, development, and demonstration leading to the ultimate commercialization of the phosphoric acid fuel cell power plant.

Before I offer our comments on the budget for phosphoric acid fuel cells, I would like to discuss the status of commercialization of this technology, the importance of the federal role today and the harm that deferrals and other discontinuities in the federal support mean to this important development effort.

The Users Group's Board of Directors on which I sit has periodically reviewed, in depth, the development programs and commercialization plan of both International Fuel Cells Corporation and Westinghouse Electric Corporation. Our Management Committee has recently reviewed the Westinghouse program and concluded that the revised effort which now includes the testing of a 1.5 MW pilot plant is appropriate and warrants our support. The International Fuel Cells program is now facing the difficult challenge of the market place - acceptance of commercial scale design and pre-commercial terms and conditions by our industry, the utility consumers. My remarks deal primarily with this challenge and the importance of an advanced technology effort in phosphoric acid fuel cells.

For many years, the developers, the electric utility industry and the federal government have been promising that fuel cell technology will soon be commercial. There are times when many of us have been questioned whether real commercialization of this technology would ever be achieved. I am sorry that I cannot yet say that it has now been achieved, but we are at a very important crossroads. The leading U.S. developer of this technology, International Fuel Cells Corporation has now placed before the electric utility industry a commercial scale offering that marks the beginning of commercialization. The significance of this event cannot be overstated, since acceptance of this offer is likely to initiate production of the first commercial scale fuel cell power plants for electric utility application. Acceptance of IFC's proposal will indicate the utility industry's willingness to make the substantial investments that this offer requires. Optimism will only be warranted as individual utilities make commitments which collectively launch the commercial application of this technology.

The utility industry, I believe, will support this initial commercialization effort because the development of this technology is important to us. However, the technology with today's costs and heat rate will be economical in certain locations and in specific applications, its current use is limited to situations with environmental and/or siting problems. What I mean is that there are urban applications, like in our service territory in New Jersey and at other constrained locations, where the fuel cell with its environmental characteristics will be a clearly advantageous technology. To obtain wide spread application of this technology, however, it will be necessary to meet lower capital cost and improved efficiency objectives, with acceptable reliability, that will yield a generator useful to large segments of the industry.

My utility is currently evaluating the commercial and technical status of this technology, and I cannot yet predict the outcome of this internal review. Speaking more generally, however, I would suggest that many utilities like ours will find suitable economic applications of this technology to afford the higher cost of some of the early commercial units. We will pay higher costs, because in certain applications they are justified, and also because we believe the technology has the potential of even lower capital costs and higher efficiencies than are now attainable, if the successes of the past joint government/private cooperation can be continued.

Our industry will make these private investments only if there is a continuing concurrent advanced phosphoric acid technology development program that will allow this capability to be reached. Since all available resources of the developer are being invested to engineer these early market units with today's technology, and to develop the necessary manufacturing capability for this early market program, and since the utility resources will be invested to purchase, install and operate these early market units, the resources for a development program that will yield breakthroughs in efficiency and capital costs must come from other sources.

The advantages of this technology primarily accrue to the public, not the electric utilities themselves. The benefits of this improved technology accrue to the utility ratepayers and the beneficiaries of environmental improvement. Particularly in today's regulatory climate, the utility is not rewarded for taking on the risks of new technology - they are more likely to be penalized. We believe that the investments being made by the developers and the utilities must be complemented by public support aimed at significant technological breakthroughs that will offer an even greater promise for the technology in the future.

The Fuel Cell Users Group, therefore, supports the funding of at least $10 million for the 7 1/2 MW and 11 MW phosphoric acid programs to ensure that the necessary technology development efforts can proceed in step with the private sector's commercialization commitments. We further support the use of Clean Coal Technology Program funding for the application of fuel cells with coal gasification. The clean use of coal can be achieved through its use with this environmentally benign generating technology.

We have reason to believe that significant cost reduction in the stacks and greater efficiency in the individual power plant components can be achieved by a new focused technology development program. With achievement of these objectives and continued improvement in reliability, this technology can achieve widespread application beyond that which would be achievable with today's technology.

We realize that the current federal budget deficit requires a belt-tightening that we will all feel. Recognizing that, it is important that the Department of Energy and Congress understand the utility industry's commitment to and interest in this technology. We have, therefore, initiated a dialogue with DOE to avoid any misunderstanding. The significant membership in the Fuel Cell Users Group and the continuing commitment by many individual utilities to the development of this technology are evidence of the historical interest. We have initiated with the Electric Power Research Institute a revised study of the market for this technology, and we will share the results with the Department of Energy and with Congress. We are intending that this be a realistic assessment, not one which paints an unrealistically rosy picture. We have opened the Users Group Management Committee meetings to Department of Energy personnel to improve their understanding of our commitment. We have offered to continue to update DOE personnel with respect to the utility industry response to the IFC offer and Westinghouse activities.

This is not an easy time to try to commercialize a technology in the electric utility industry given the large reserve margins, declining fuel costs, uncertain load growth and the financial pressures of completing large construction programs. Despite these events, we believe commercialization of this technology can be successful because it is so important to many utilities in the United States.

Mr. Chairman, in commenting on the need for federal monies for development of this technology, I should note that the program of the Westinghouse Electric Corporation also offers significant promise for the industry. I have not dwelled on this program because its technology development agenda is clearly defined and understood by both the federal and private communities and does not yet present the same commercialization opportunities. We do, however, support the funding of both technology development efforts in the hopes that phosphoric acid fuel cell technology will be available from one or more domestic U.S. suppliers in the near future and will be widely applicable throughout industry in the 1990s.

Mr. Chairman, I thank you and the Committee for your interest in this attractive technology. I encourage your continued support. I will be happy to respond to any questions or comments on my remarks.

THE
UNIVERSITY
OF UTAH

DEPARTMENT OF FUELS ENGINEERING
320 W. C. BROWNING BUILDING
SALT LAKE CITY, UTAH 84112-1183

March 5, 1986

Honorable Don Fuqua
Chairman Subcommittee on Energy Develonment and Application
Committee on Science and Technology
2269 Rayburn House Office Building
U.S. House of Representatives
Washington, D. C. 20515

ATT: Mr. Bill Harvey

Re: DoE Fossil Energy Budget Hearings

Dear Representative Fuqua:

The Departments of Fuels Engineering, Metallurgical Engineering, and Chemical Engineering of the University of Utah have been conducting research for the development of U.S. tar sands for the past 12 years (see chart). As far as we know, our program is currently the only active program in the U.S. researching mining and above-ground technology recovery. Over the past 12 years we have achieved notable success in developing the scientific and engineering data necessary for commercialization of this important resource. The faculty members working on the program possess extensive industrial experience and are highly regarded. We have been called upon frequently by government and industry to supply information for their studies and to assist in their decision-making process.

No less than a dozen major energy and engineering companies have visited our facilities to obtain information for in-house programs and for assisting in corporate decisions regarding leasing and development. At least one significant company merger can be directly attributable to the results supplied by our work. We have no good way of valuing other less tangible benefits. However, over 20 M.S. and PhD. degrees have been granted in our tar sand program and the list of scientific publications resulting from the program now number more than 60. The state of Utah, which with its major tar sand resources makes it the 2nd largest petroleum resource state in the union, has an active interest in tar sand development. Since 1981 Utah has matched $1 for every $2 in research funding provided by DoE for our program.

We have recently learned that the DoE budget proposed for FY '87 calls for no further funding of tar sand research. We feel that discontinuing funding of tar sand research would result in significant adverse impacts for the country. First, it must be understood that domestic tar sand resources are petroleum-like in nature and products from this resource are more readily refinable than would other unconventional sources of hydrocarbons. Tar Sands could contribute to our nation's energy supply in the shortest period of time, but additional research is required before this will happen. Second, economics of commercialization do not appear to be necessarily the major constraint to development. A far greater constraint in our judgement is the fragmented lease positions in which logical development units have never been delineated. This has resulted in a situation, especially in Utah and perhaps elsewhere, in which leases are generally held by speculators with no research ability while major industry, with the research ability, does not hold the leases and has little incentive to either block up the leases or invest funds in research.

Third, the technological research needs relate principally to the variability in the resource, both geological and chemical. These variations prohibit direct adaptation of technology developed for Alberta, Canada resources. As a matter of interest, Alberta has consulted with us on various occasions regarding our findings to assist in their future developments. We feel there is a high probability that some of our technology will prove applicable to their developments.

The current DoE program, as modest as it is, represents the one focal point of information and expertise currently available on U.S. tar sands that could serve as a nucleus for future developments. Discontinuing funding would effectively stop tar sand research and would result in a disbanding of the expertise currently available. The state of Utah would also be effectively taken out of the program because Utah could not carry on significant tar sand research alone without the federal government contributing to this work.

In our judgement a slightly accelerated program from FY '86 would result in a commercial plant of modest size in as little as 5 years. The primary product would be asphalt which we feel is currently profitable. We have recently learned that the U.S. is importing significant quantities of asphalt produced from Canadian tar sands and there is an appreciable market for such products in Utah and surrounding states. Asphalt is expected to become an increasingly important commodity as our current generation highways require resurfacing. An unconventional hydrocarbon commercial plant would greatly assist our state and national confidence that such development could contribute to our nation's energy security.

It is our consensus that the current downturn in world oil prices is temporary and partly artificial and could portend a swing in the opposite direction of equally major proportions. Now seems to be the most opportune time to conduct the necessary research so that the technology is ready when needed. In our judgement the venture pool approach proposed by DoE will not work with tar sands. The research is not sufficiently advanced nor is information available for the ventures to be successful even if participants could be identified. If the base research program is discontinued there would be no central place for ventures to gather information. Maintaining the current research effort at a comparable level to FY '86, but shifting the focus slightly toward shorter term commercialization is the best way to proceed at this time. It is our understanding that this recommendation is also consistent with that of the state of Utah.

We appreciate your consideration of our testimony and would be pleased to have this entered into the record for your committee hearings.

Sincerely,

Alex G. Oblad, Principal Investigator
Distinguished Professor of
Metallurgical and Fuels Engineering
Member, National Academy of
Engineering

Co-Investigators:

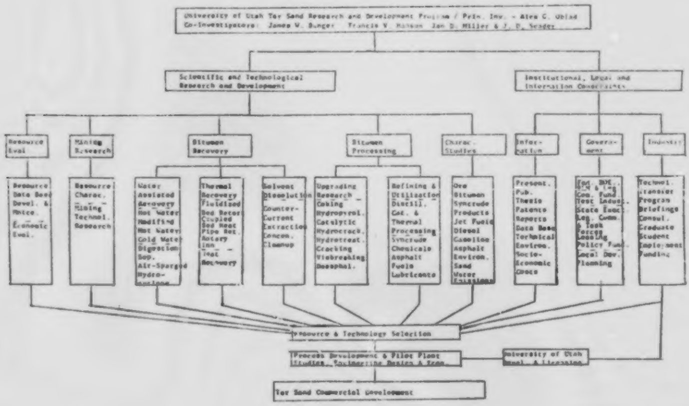
James W. Bunger
Research Assistant Professor

Francis V. Hanson
Professor of Fuels Engineering

Jan D. Miller
Professor of Metallurgical Eng.

J. D. Seader
Professor of Chemical Engineering

cc: Utah Congressional Delegation..


University of Utah Tar Sand Research and Development Program / Prin. Inv. - Alex G. Oblad
Co-Investigators: James W. Bunger Francis V. Hanson Jan D. Miller & J. D. Seader
Scientific and Technological Research and Development
Institutional, Legal and Information Constraints
Resource Eval.
Mining Research
Bitumen Recovery
Bitumen Processing
Charac. Studies
Information
Government
Industry
Resource Data Base Devel. & Maint. Economic Eval.
Resource Charac. Mining Technol. Research
Water Assisted Recovery Hot Water Modified Hot Water Cold Water Digestion Sep. Air-Sparged Hydrocyclone
Thermal Recovery Fluidized Bed Retort Coupled Bed Heat Pipe Ret. Rotary Kiln Heat Recovery
Solvent Dissolution Counter-Current Extraction Concen. Cleanup
Upgrading Research Coking Hydropyrol. Catalytic Hydrocrack. Hydrotreat. Cracking Visbreaking Deasphal.
Refining & Utilization Distill. Cat. & Thermal Processing Syncrude Chemicals Asphalt Fuels Lubricants
Ore Bitumen Syncrude Products Jet Fuels Diesel Gasoline Asphalt Environ. Sand Water Emissions
Present. Pub. Thesis Patents Reports Data Base Technical Environ. Socio-Economic Goals
Policy Fund. Local Dev. Planning
Technol. Transfer Program Briefings Consul. Graduate Student Employment Funding
Resource & Technology Selection
Process Development & Pilot Plant Studies, Engineering Design & Econ.
University of Utah
Tar Sand Commercial Development

American Chemical Society

OFFICE OF THE
PRESIDENT

George C. Pimentel
President-Elect, 1985
President, 1986
Immediate Past President, 1987

1155 SIXTEENTH STREET N W
WASHINGTON D C 20036
Phone (202) 872-4600

March 7, 1986

The Honorable Don Fuqua
Chairman
Subcommittee on Energy Development and Applications
Committee on Science and Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

The American Chemical Society appreciates this opportunity to present its views on the Department of Energy's FY 1987 budget request for Fossil Energy. The Society believes the drastic cutback proposed for the Fossil Energy R&D budget is ill-advised. As a Nation, it is easy to give short shrift to energy issues when we are not faced with crisis situations; however, the long-term needs of the United States indicate that we cannot ignore the energy area. The Society's major recommendations are summarized as follows:

- Long-range coal research programs should be increased by \$19.0 million over the budget request of \$22.9 million. This should be considered a priority item in Fossil Energy.
- Other Fossil Energy programs should be restored to the FY 1986 appropriated levels.

A substantial portion of Fossil Energy R&D is connected to coal research. The 1985 Report, Opportunities in Chemistry, states that:

> Coal is the most abundant of the fossil fuel energy sources. Estimates of recoverable supplies worldwide indicate 20 to 40 times more coal than crude oil. The contrast is even more dramatic here in the United States where the estimates indicate 50 to 100 times more coal than crude oil. There can be no doubt that dependence on coal must increase during the next two or three decades...(1)

Since the Fossil Energy Research and Development program is directly responsible for producing the energy technology necessary for our future energy needs, sustained support of this R&D program is essential. Japan is becoming heavily involved in coal research. When coal becomes the primary energy source of choice, improved utilization of coal by Japan will result in manufacturing

---

1. National Research Council, Opportunities in Chemistry (Washington, D.C.: National Academy Press, 1985), p. 38.

efficiencies and increased competition for the U.S. The United States has the opportunity to stay ahead if it nurtures its coal research base.

It is indeed unfortunate that cutbacks are being proposed at a time when the opportunities for advancement have never been greater. Today, new spectroscopic techniques, chemical procedures, and theoretical understanding are available to probe the structure and reactions of non-crystalline solids. New, in situ diagnostic tools and computer modeling techniques are being advanced for accurate determination of process behavior. The potential exists for rapidly developing new knowledge that could lead to revolutionary high technology processes for utilizing solid feedstocks in an environmentally safe and cost effective manner.

To utilize these resources properly, stable, continuous long-range R&D programs are needed to provide a sound, high technology foundation on which to select and implement the process alternatives. Unfortunately, U.S. capacity for fossil fuel research has been severely reduced. Recent mergers in the petroleum industry have resulted in substantial cutbacks in industrial research activities on alternative energy sources. Also, the present abundance of oil, the duration of which is uncertain, has led to the dismantling of many other alternative fossil fuel research efforts.

At the present levels of support, it will be difficult to maintain sound technical expertise and adequate training of new scientific and engineering talent in the technologies of coal, oil shale, and tar sands. Unless corrected, this situation will jeopardize the ability of the U.S. to respond effectively to the next oil shortage.

The ACS is distressed at the drastic reduction proposed for the Fossil Energy budget. The Society sets a high priority on the long-range coal research effort and recommends that the FY 1987 Fossil Energy budget items for long-range coal research(2) be increased by $19.0 million to $41.9 million; this would provide a 20 percent increase over the FY 1986 budget levels. The Society asks that your Subcommittee consider reprogramming funds from the $400 million recently established in the Clean Coal Technology program to support these budget items. Also, the remainder of the Fossil Energy budget should be restored to the FY 1986 appropriated level to insure that research results can be tested on a realistic scale. (The accompanying Appendices I and II give a budgetary history.)

Times of economic stress are times of difficult priority choices; a time for retreat in some areas, and a time for increased investment in areas that will guarantee future progress. Japan has already identified and intends to provide additional support to these same energy-related research areas.(3)

---

2. Coal liquefaction advanced research; surface coal gasification advanced research; and advanced research and development direct utilization, materials, and university coal research.

3. "Recommendation of the Council for Science and Technology on the 11th Inquiry titled, 'Comprehensive Fundamental Policy for Promotion of Science and Technology to Focus Current Changing Situations from the Long-term View,'" The Council for Science and Technology, Japan, November 1984.

A number of U.S. scientific programs that involve much larger expenditures are under consideration. They show that the increases recommended by ACS would be modest investments, but ones directly relevant to the DOE mission.

In addition, for the most efficient use of our research investment, the ACS supports a competitive, merit-based peer-review process as the primary mechanism for selection of research and instrumentation proposals for large-scale centers and facilities. The Conference Report on HUD-Independent Agencies Appropriations (H.Rpt.99-363) endorsed such a principle. It is hoped that this Subcommittee will issue a similar statement of support.

The ACS appreciates the opportunity to express its views. The Society believes the costs of our recommendations are minimal compared to the many potential benefits to be derived in helping to insure a stable, long-range energy supply in the U.S. and in reducing our vulnerability to the uncertainties of foreign oil supplies.

Sincerely yours,

George C. Pimentel

Appendices

cc: Other Members, House Science and Technology
Subcommittee on Energy Development and Applications

Long-Range Coal Research Programs
[Programs under Advanced Research and Technology Development(a)]
(Dollars in Thousands)

	Surface Coal Gasification Advanced Research	Coal Liquefaction advanced Research	Direct Utilization	Materials	University Coal Research	TOTAL
1980	$14,800		$ 7,100	$ 7,000	$ 5,000	$33,900
1981	20,400		9,100	7,000	5,000	41,500
1982	18,624		10,368	7,680	5,184	41,856
1983	7,500		10,600	6,940	2,750	27,790
1984	3,650	$ 5,350	11,250	7,000	4,000	31,250
1985	3,364	5,510	9,990	7,733	4,425	31,268
1986(b)	3,379	5,157	11,262	6,899	5,622	35,054
1987(c)	968	2,620	9,415	5,860	4,000	22,863

a. Until 1986, Coal Liquefaction Advanced Research and Surface Coal Gasification Advanced Research were funded under Advanced Research and Technology Development as the Processes subprogram.

b. Enacted budget, after 4.3% reduction due to Gramm-Rudman-Hollings deficit reduction legislation.

c. Administration's Budget Request.

Source: Budget Justification Books for the Department of Energy.

BEST COPY AVAILABLE

APPENDIX II

Federal Support for Fossil Energy R&D Program
Fiscal Years 1971-87*
(Dollars in Millions)

ACTUAL									
1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
36	38	49	88	312	369	557	687	668	727

ACTUAL					GRAMM-RUDMAN	REQUEST
1981	1982	1983	1984	1985	1986	1987
650	408	268	278	292	284	150

* Includes funds for the Department of the Interior programs, 1971-76, transferred to DOE in 1977.

Sources:
The budget figures for 1971-81 are from the National Science Foundation "Federal R&D Funding for Energy: Fiscal Years 1971-84" (NSF 83-301). The 1982-87 budget figures are from the Department of Energy. The figures do not include construction, capital equipment, and program direction. The 1986 and 1987 budget figures do not include funds in the Clean Coal Technology program that was mandated by Congress.

Statement by Frank C. Schora, President
HYCRUDE Corporation
Before the House Committee on Science & Technology
Subcommittee on Energy Development & Applications
Hearings on Department of Energy FY'87 Budget

March 4, 1986

Mr. Chairman and Members of the Subcommittee:

My name is Frank C. Schora. I am president of HYCRUDE Corporation, which was formed in 1980 specifically to further research and development efforts for production of synthetic crude oil from Eastern U.S. oil shales.

Eastern oil shale is a vast resource which will one day provide our nation with an indigenous supply of synthetic crude oil, upon which our transportation and defense systems depend. The decline of oil spot prices to below $15 per barrel does not encourage the immediate development of an eastern shale oil industry by the private sector. It is imperative, however, to provide a modest level of federal funding for eastern oil shale research programs so that in the future we will have the ability to respond to inevitable oil price increases. To reduce R&D efforts below present low levels will result in a loss of technical expertise in these areas which will take years to rebuild.

Eastern oil shale has previously been considered a secondary resource. The eastern and western oil shale deposits are totally different, both geologically and chemically, as pointed out in DOE's own oil shale program plan. The western oil shale deposits are in general deep mined, yield 25-30 gallons of oil per ton when retorted by conventional technologies and are located in sparsely populated areas. In contrast, the eastern oil shale deposits are surface mineable, require specialized retorting technologies to obtain oil yields in excess of 25 gallons per ton and are located in a more populous region of the country which is in close proximity to process water, skilled work forces, oil refining capacity, distribution systems and markets. These drastic differences in the nature of the two resources and the environment which surrounds them invalidate a "generic" research program.

The only studies which can be usefully performed generically are basic thermodynamic studies and the development of process simulation computer programs. In fact, work sponsored by DOE supports the conclusion that little generic work can be performed in either the Technology Base or Environmental Mitigation Areas. A study performed by Los Alamos National Laboratory concludes that Eastern oil shale requires substantially different retorting technologies than the western oil shale resouce in order to obtain the most economical recovery of oil. The study shows that moving-bed hydroretorting, which was developed specifically for the eastern shale resource, produces oil from eastern shale at a substantial cost savings compared to the TOSCO and Paraho processes developed for operations involving western shale. Furthermore, the study concludes that much more research would have to be conducted on these "western" shale processes before they could be applied to eastern shale because of chemical differences in the resources.

In addition to the distinctly different process technologies required to fully utilize eastern and western oil shales, it must be recognized that the two resources are located in entirely different ecosystems. The differences in shale chemistry and the environment in which the resources are located dictate that separate environmental research activities also be conducted for the Eastern oil shale resource.

For example, a study performed under DOE sponsorship by Ultrasystems concludes that residuals of potential pollutants remaining in retorted shale is dependent upon the type of shale and retorting process utilized. Therefore, the tendency of retorted shales to leach and pollutants which may potentially be found in the leachates are not to be expected to be the same for eastern and western shale.

In recognition of the unique research needs of Eastern oil shale, your Subcommittee participated in the establishment of an eastern oil shale research program in FY'85, and its continuation in FY'86. As a result of the establishment of this program, several important research efforts have been initiated including:

* expansion of the data base for moving-bed hydroretorting, a process which has been proven to obtain oil yields for eastern shales approximately twice as high as would be obtained if conventional retorting methods were utilized.

* research on the beneficiation of various Eastern oil shales.

* the establishment of a Program Research and Development Announcement (PRDA) for novel concepts.

It is important to maintain an eastern oil shale research program to complete the projects listed above and to make efficient use of the results obtained in these programs.

HYCRUDE Corporation recommends $1.5 million in FY'87 to continue the research program on expanding the data base for moving-bed hydroretorting of Eastern oil shales, for investigation of fluidized-bed hydroretorting of both raw and beneficiated Eastern oil shales, and for investigating the recovery of strategic metals form spent shale.

HYCRUDE Corporation also recommends $1.5 million to continue the eastern shale beneficiation program and to investigate the recovery of strategic metals from beneficiation effluent streams, the removal of pyritic sulfur from shale during beneficiation and subsequent microbial removal of organic sulfur, and the effects of water recycling on the beneficiation process.

HYCRUDE Corporation also recommends $2.0 million for the continuation and expansion of the novel concepts research program; $1.0 million for support research activities such as gathering thermodynamic, chemical and physical properties data for all researchers; and $1.0 million for environmental studies.

In conclusion, exact duplication of all western shale research in the DOE program on an eastern shale will not contribute useful data for eastern shale development. The requirements for development of eastern shale from both a retorting technology and environmental standpoint are unique. A specific program to address the research needs for Eastern oil shale is mandatory.

HYCRUDE CORPORATION

Selected Energy Research

Recommendations FY'87

PROGRAM FACT SHEET

Pressurized Hydroretorting Research:

Pressurized moving-bed hydroretorting is a process which demonstrates that it is possible to obtain similar oil yields for eastern and western oil shales with comparable organic carbon contents. Because conventional retorting of Eastern oil shales results in much lower oil yields than those obtained for western oil shales, the Eastern oil shales were previously considered to be a leaner resource. It was discovered, however, that Eastern oil shale is deficient in hydrogen. The addition of hydrogen at elevated pressure during retorting, such as in moving-bed hydroretorting, results in dramatically increased oil yields.

As a result of the eastern oil shale research program established by Congress in fiscal year 1985, a three-year initiative was undertaken to expand the data base for moving-bed hydroretorting of a variety of Eastern oil shales. The results of this research will provide investigators with comprehensive environmental and process data, as well as a better understanding of the relationship between oil shale chemical characteristics and moving-bed hydroretorting oil yields for a variety of Eastern oil shales. The existing project addresses improvements to the moving-bed hydroretorting process technology and/or economics by:

* investigating the gasification of raw shale fines which cannot currently be processed in the moving-bed retort. Recoverable fines, which are generated during oil shale crushing represent up to 10% of the resource.
* investigating retorting in a synthesis gas atmosphere. Utilization of synthesis gas produced by the gasification of fines could help reduce or eliminate the hydrogen requirements of retorting.
* investigating a mist generation system which will control the maximum size of oil droplets formed during retorting. This will minimize the condensation of oil droplets on shale particles and the subsequent refluxing and revaporization which results in thermal cracking of oil to gas and reduced oil yields.
* further investigating the utilization of raw shale fines by increasing the tolerance of the moving-bed to accept fines. This work consists of research to determine the minimum particle size allowable at various solids and gas flow rates.

The results obtained in this program and a federally-sponsored eastern oil shale beneficiation program are providing direction for the development of a second generation pressurized hydroretorting technology. Pressurized hydroretorting of beneficiated oil shale produces an oil yield which is approximately four times the yield obtainable by conventional retorting of non-beneficiated oil shale. Preliminary studies indicate that the combination of beneficiation and pressurized hydroretorting technologies has resulted in oil yields of up to 54 gallons per ton.

However, beneficiated shale, which is very finely ground, must be briquetted in order to be processed in a moving-bed technology. Pressurized hydroretorting of beneficiated shale in a fluidized-bed with an inert solids material will allow direct processing of the beneficiated shale. The inert material (sand) in the bed will aid heat transfer, promote uniform mixing, and hold the beneficiated shale in the fluidized bed for sufficient residence time.

Eastern oil shales such as Tennessee Chattanooga shale contain significant quantities of strategically important metals such as vanadium, molybdenum, nickel, chromium, and manganese. Recovery of these metals from spent oil shale could reduce our Nation's dependence upon imports of these metals while providing important environmental benefits. Techniques for recovering strategic metals from hydroretorted shale should be investigated.

HYCRUDE Corporation recommends $1.5 million in FY'87 for continuing the research program on expanding the data base for moving-bed hydroretorting of Eastern oil shales, for investigating fluidized-bed hydroretorting of both raw and beneficiated Eastern oil shales, and for investigating the recovery of strategic metals from spent shale.

Beneficiation Research:

In the beneficiation process, oil shale is finely ground and a high proportion of the inert mineral matter is separated from the organic rich portion of the shale. Beneficiation produces a greatly enriched feedstock, which can be retorted by conventional means, or by hydroretorting for even more dramatically increased oil yields. Because the feedstock is enriched, the capital cost for the retorting process is reduced.

Beneficiation can increase the number of Eastern oil shales which can be considered for retorting. In addition to the richer shales of Alabama, Indiana, Kentucky, Michigan, Ohio and Tennessee, leaner deposits in West Virginia, Illinois, Pennsylvania and New York can be enriched to the point where retorting is viable.

Fundamental research is now being conducted on beneficiation of Eastern oil shale and on moving-bed hydroretorting of beneficiated shales. A three-year research effort was initiated as a part of the eastern oil shale program mandated by Congress in FY'85. The beneficiation characteristics of various Eastern oil shales will be investigated, and the hydroretorting oil yield will be determined.

Additional research activities which should be conducted in the area of eastern oil shale beneficiation include:

* Determination of the separation of characteristics of various Eastern oil shales as a function of particle size, and the efficiency of various floatation agents.

- Identification of strategic metals present in the effluent streams from the beneficiation process and determination of the technical and economic feasibility of metals recovery techniques.

- Assessment of the effects of water recycling on the beneficiation process.

- Investigation of concepts for sulfur removal from the beneficiated oil shale.

- The biological removal of nitrogen and sulfur compounds is currently being investigated for coal. The microbial removal of sulfur and nitrogen from oil shale would result in a higher quality oil product and a cleaner product gas stream. Microbial denitrification and desulfurization from the product shale oil should also be investigated.

HYCRUDE Corporation recommends $1.5 million in FY'87 for continuing oil shale beneficiation research.

Novel Concepts Research:

As a result of the eastern oil shale research program established by Congress, awards will be made to investigate novel concepts which have the potential to improve the economics or environmental impact of eastern shale retorting. The continuing support of novel concepts research will ensure the development of state-of-the-art retorting technology. Some promising novel concepts are discussed briefly below.

- By supplying the activation energy for the formation of oil from shale through radiation (at ambient temperature and pressure), it is possible to achieve a dramatic increase in oil yields with donor solvents. This concept has the potential to be integrated with beneficiation because the beneficiated product is in a slurry which can be processed directly by radiation donor solvent treatment.

- Microbial in-situ recovery of shale oil may provide a low cost method for oil recovery because the capital costs required for mining, reclamation and retorting would be eliminated.

- Replacement of the lockhopper systems from high pressure operations on solids, such as spent shale extraction from the retort, would provide substantial savings. Research on continuous techniques for the removal of solids, such as dissipating the pressure through a properly designed discharge pipe system, should be conducted.

- Catalytic retorting of oil shale can provide a technique for increasing oil yields. Doping of raw shale with catalysts has previously been shown to enhance resource recovery. This concept needs to be investigated utilizing beneficiated oil shale where the potential for greater yield enhancements exists.

- The use of spent oil shale use for the production of cement will provide a method for utilizing the spent shale, thereby reducing spent shale disposal concerns. Preliminary testing has indicated that a viable product can be developed.

HYCRUDE Corporation recommends $2.0 million in FY'87 for continuing novel concepts research.

Support Research:

There are a variety of fundamental support research activities which should be undertaken to provide researchers with thermodynamic, chemical and physical properties data for Eastern oil shale. These data are necessary to improve the understanding of oil shale retorting and will aid in the assessment of results obtained in the other eastern oil shale research program areas. Several examples of support research activities are discussed below.

- Reaction kinetics modeling is essential to an understanding of eastern oil shale retorting and, in specific, oil loss mechanisms. Knowledge of the mechanisms of oil production will lead to new techniques for increased oil recovery from the shale. kinetics modeling can allow research to address areas such as product quality and product mix, oil production versus gas production.

- Research concerning the primary reaction products of eastern shale retorting is necessary for an understanding of the oil shale resource and effects of variations with the shale deposits on retorting products. Process research does not indicate what the primary reactions (which result in a release of oil products from the shale) are because it measures product stream components after secondary gas phase reactions. Knowledge of these primary reaction products will vastly improve the results of kinetics modeling efforts.

- Research on physical, chemical and thermodynamic shale properties should be conducted. Research to define mechanical properties such as particle integrity, crushing characteristics and thermal properties such as specific heat and heats of reaction is necessary for efficient process design.

HYCRUDE Corporation recommends $1.0 million in FY'87 for continuing Eastern oil shale support research activities.

Environmental Studies:

In addition to the environmental process research, it is necessary to conduct environmental studies. These studies should address topics such as the seasonal availability of water.

Baseline data on existing point sources of sulfur and nitrogen oxides should also be gathered.

The results of these studies will provide direction for retorting process optimization (i.e. water consumption and/or product gas desulfurization and denitrification).

HYCRUDE Corporation recommends $1.0 million in FY'87 for continuing environmental studies.

Testimony Before the House Subcommittee on Energy Development of the House Committee on Science and Technology Regarding the FY 1987 Budget Authorization Request for DOE Program on Fossil Energy

Scheduled for March 4, 1986, 9:30 A.M.
2318 Rayburn House Office Building
Washington, D.C.

by

Walter R. Hibbard, Jr.
Director, Virginia Center for Coal and Energy Research
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24060

Thank you for the opportunity to testify before the Subcommittee on the very important issue of support for the DOE Fossil Energy Program. I have been active in fossil energy research for many years, including past Director of the U.S. Bureau of Mines, as well as Coal Specialist and Acting Deputy Director of the Energy Research and Development Office of the Federal Energy Office (later Federal Energy Administration, then ERDA). A short biographical sketch is attached.

Essential to the stability of economic growth and national security is a reliable supply of fossil fuels. In view of the uncertainty of the supply and the instability of price of imported oil and gas, as well as the shrinking long-range availability of domestic oil and gas, it is essential that optimum use be made of our large, reliable, and stable supply of domestic coal.

Concerns about acid precipitation; the "greenhouse" effect and other environmental effects of burning coal; and the nuisance of handling fuel and ash have limited the acceptance of coal as a substitute for oil and/or gas — without full realization of that decision's impact on imports, economic growth, and national security. Jobs are exported with each import, even though coal is our least expensive, though inconvenient, source of electricity.

An era of oil and gas gluts lead us to forget that when the economies of Europe, Asia, and South America are fully recovered oil demand will rise, the glut will disappear, and prices will rise again to peak levels. Developed countries in Europe and Japan are still largely dependent on Mid-East OPEC oil. When the next oil price shock occurs, the U.S. must be fully prepared with viable alternatives to oil, since under IEA agreements the U.S. must share with other member nations the effects of oil price shocks.

New technology is necessary to make coal fully competitive in convenience and acceptability with oil and natural gas. The following developments are on the verge of viable new technologies to achieve these goals:

Utility-size fluidized bed combustors which will provide enhanced environmentally benign, burning of coal for electricity generation.

Integrated coal gasification and combined cycle systems for electricity generation to benignly replace oil and natural gas.

Coal liquids, including coal-water mixtures and pyrolytic coal-oil mixtures, which can replace fuel oil and diesel oil made with petroleum.

Coal cleaning techniques which can refine coal to match the quality of petroleum products (though not yet in price).

All of these technologies are being developed jointly with the DOE fossil energy program by projects at United Coal Company, Atlantic Research Corporation, and Virginia Tech, as well as by projects at other Commonwealth institutions. These developments are close to becoming reality, but need expensive demonstration plants and long-term reliability trials beyond the resources of the above named Virginia institutions and Commonwealth budgets.

These final steps are critical. Abandonment of the projects will waste significant investments made so far, as well as creating road blocks to the acceptability of coal as a fossil fuel relative to oil and gas. Expensive fuel imports, job exports, and balance of payments problems will be extended if the program is abandoned.

Therefore, it is vigorously recommended that the aforementioned projects be sustained in the FY 1987 Budget Authorization for the DOE fossil energy program. These program areas must be preserved for the welfare of the nation.

Walter R. Hibbard, Jr.
University Distinguished Professor of Engineering
Virginia Polytechnic Institute and State University

Walter R. Hibbard, Jr. is a University Distinguished Professor of Engineering and Director of the Virginia Center for Coal and Energy Research at Virginia Polytechnic Institute and State University, Blacksburg, Virginia. In 1974, he served as Deputy Director and Specialist on Fossil Fuels in the Energy Research and Development Office of the Federal Energy Office. From 1968 to 1974, he was Vice President of Technical Services in the Owens-Corning Fiberglas Corp., Toledo, OH. Dr. Hibbard is a member of the Board of Directors of the Norton Co. in Worcester, Massachusetts.

He served as Director of the Bureau of Mines in the U.S. Department of the Interior, Washington, D.C. from 1965 to 1968. Prior to this appointment he was manager of the Metallurgy and Ceramics Department of General Electric Research Laboratory, Schenectady, New York. After serving as a reserve officer in the U.S. Department of the Navy's Bureau of Ships during World War II, Dr. Hibbard taught Metallurgy in the School of Engineering at Yale University. He also served as an adjunct professor of Metallurgy at Renssalaer Polytechnic Institute.

Dr. Hibbard is a member of the National Academy of Engineering and served on its committee on Public Engineering Policy. He was Chairman of the Materials Advisory Board and also the Building Research Advisory Board of the National Research Council. He served on the National Academy of Sciences' Committee on the Survey of Materials Science and Engineering (COSMAT). He is a Fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, the American Ceramic Society, the American Society for Metals, and the Metallurgical Society of A.I.M.E. He is a Distinguished Member of the Society of Mining Engineers. He was President of the American Institute of Mining, Metallurgical, and Petroleum Engineers for 1967-1968, and he received their James Douglas Gold Medal, Rossiter W. Raymond Award, and Mineral Economics Award.

He graduated from Wesleyan University with a degree in Chemistry and received his doctorate in Engineering from Yale. He has received honorary degrees from Michigan Technological University and from Montana College of Mineral Science and Technology. He is a registered professional engineer in the states of Virginia, Ohio and Connecticut. He received the Yale Engineering Association Award for the Advancement of Science and Engineering in 1955 and the Wesleyan University Distinguished Alumnus Award in 1979. He is Editor in Chief of the journal, Materials and Society.

TESTIMONY BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
UNITED STATES HOUSE OF REPRESENTATIVES

4 March 1986

LaPorte Indirect Coal Liquefaction Process Development Unit and Supporting Research and Development

by

Dr. George W. Roberts
General Manager, Commercial Development Division
Process Systems Group
Air Products and Chemicals, Inc.
Allentown, PA 18105

LaPorte Indirect Coal Liquefaction
Process Development Unit and
Supporting Research and Development

Introduction

Good morning, Mr. Chairman and Members of the Subcommittee. I am George Roberts of Air Products and Chemicals, Inc. I appreciate the opportunity to appear before you and testify at these hearings.

At Air Products we are continually seeking, developing, and commercializing new technologies. One such technology is an indirect coal liquefaction process called Liquid Phase Methanol (LPMEOH*) which has the potential to enhance the use of domestic coal by our electric utility industry. Air Products has been developing the LPMEOH process jointly with the Department of Energy (DOE) since 1981. This research has been going very well and can be successfully concluded if the Congress and the DOE provide additional funding to permit Air Products to follow the technical plan that was formulated several years ago. On the other hand, if the work cannot be completed for lack of funds, a major opportunity to advance a federally sponsored technology towards commercialization will have been lost.

I am here today to urge the Subcommittee to provide financial support for the final phase of the LPMEOH project. Specifically, I request the authorization of an additional $5.4 million in the DOE's FY 1987 Fossil Energy Research and Development budget, with these funds earmarked for operation and support of the DOE Indirect Liquefaction Process Development Unit (PDU) at LaPorte, Texas.

Several very successful LPMEOH runs have been completed since the unit was started up in March 1984. We have developed a strong data base and we feel the technology will be positioned for commercial-scale demonstration at the conclusion of this final phase of the development program.

To support this request for funding, I will: 1) briefly summarize the status of the current research program; 2) outline plans for the final phase of research; and 3) outline plans for future demonstration and commercialization of the LPMEOH technology.

Current Status

The LPMEOH technology research was begun at the laboratory bench scale in 1975 by Chem Systems Inc., the originator of the process. The financial support for this early work was provided by the Electric Power Research Institute (EPRI). The DOE's participation in this technology began in 1981 when a contract was awarded to Air Products, with Chem Systems as a key subcontractor. The objective of this contract is to prove the feasibility of the LPMEOH process in a 5-tons-per-day LPMEOH Process Development Unit (PDU) at LaPorte, Texas. Private cost-share funding was provided by EPRI, Fluor Engineers and Constructors, Inc., and Air Products. A second contract to continue LPMEOH research and engineering support studies was initiated in July 1985, again with substantial private cost sharing. Under these contracts, the LPMEOH PDU was successfully commissioned and operated, and five LPMEOH process runs were conducted between March 1984 and July 1985.

---

*A trademark of Chem Systems Inc.

As a result of these development efforts during the past 4 years, the LPMEOH technology has been substantially advanced, and we have developed a significantly greater understanding of the fundamentals of the process. The major achievements of the program include:

- Operation of the LaPorte PDU for an aggregate of over 2,500 hours under a wide range of operating conditions, with on-stream reliability in excess of 98%.
- Development of a novel procedure for activating the catalyst that works even with high-concentration catalyst slurries (up to 45 wt %).
- Extension of catalyst life through the understanding of catalyst poisoning mechanisms and development of techniques to reduce poison formation. At this point, we project that catalyst life in the LPMEOH process will be equal to or better than catalyst life in conventional, gas-phase methanol processes.
- Development of a computer process model that successfully predicts lab-, bench-, and PDU-scale performance.

The foregoing achievements are extremely encouraging from the standpoint of eventual process commercialization. However, the work to date has exposed some limitations of the current reactor design and has suggested some directions for improving reactor performance. For example, we are currently doing engineering studies to improve mixing and heat transfer within the reactor, and to design a system for continuously adding and withdrawing catalyst.

As a result of funds authorized for the LPMEOH project by this committee in FY 1986, a third, 18-month contract will be finalized between DOE and Air Products in July 1986. The objectives of this third phase of the program are to modify the LaPorte PDU to incorporate and test process improvements identified in the second contract, to demonstrate long-term maintenance of catalyst activity in the laboratory, and to further strengthen the LPMEOH database.

Program for FY 1987

Last year, at these hearings, I presented a plan and requested a total of $10.5 million for two years of additional work in the LaPorte PDU and in the laboratory to fully develop the data required to support the design and future operation of an LPMEOH demonstration plant in the 100 to 200-tons-per-day range. This committee saw fit to authorize $5.1 million for FY 1986 as the first installment for this program. However, as a result of cuts mandated by the Gramm-Rudman Act, we anticipate receiving $4.8 million of DOE funds in FY 1986. We are still operating on the basis of the original plan and now see the need for a final government investment of $5.4 million in FY 1987 to successfully conclude the LPMEOH development work at the LaPorte PDU scale.

The proposed 14-month research program will focus on:

- Conducting extended, continuous runs at LaPorte (approximately 4-6 months duration) to obtain critical data on the catalyst durability and poison resistance.

- Evaluating the long-term performance of the reactor modifications implemented in the FY 1986 program.
- Completing the laboratory bench-scale research to assure technical success of the LPMEOH process at the next scale of demonstration, in which it will be integrated with a coal gasifier. A critical need is to develop and field-demonstrate a system to remove catalyst poisons from coal-derived syngas.

We will supplement this request for $5.4 million of funding by committing private cost-share funds of $700 thousand to this concluding phase of the LaPorte program. This level of private cost-share funding is consistent with our contributions in the prior LPMEOH contracts. We have also invested additional funds in proprietary R&D in this technology. The LaPorte program is a key element in our LPMEOH development efforts. It provides us a cost-effective way of performing research and development to obtain the engineering data vitally needed to move the LPMEOH process to the next logical step, which is a demonstration with coal-derived synthesis gas on a much larger scale.

Demonstration and Future Commercial Development

The application of the LPMEOH process in conjunction with Integrated Gasification Combined Cycle (IGCC) power production is very attractive to the U.S. electric utility industry as an environmentally safe and acceptable way to use abundant domestic coal reserves for power generation. It is a viable alternative to conventional coal combustion and its associated problems of acid gas and nitrogen oxides emissions. To advance the LPMEOH process towards commercialization in this application, Air Products, Chem Systems, EPRI, and the Tennessee Valley Authority (TVA) are developing plans to demonstrate the technology at a scale of 35 tons per day at TVA's Muscle Shoals, Alabama, coal gasification facility. In this project, which we have termed "Once-Through Methanol (OTM) Demonstration," a portion of the synthesis gas from TVA's 200-tons-per-day Texaco coal gasifier will be fed directly to the LPMEOH plant. The syngas will be partially converted to methanol in a single pass through the reactor (hence the term "once-through methanol"). In full-scale commercial application, the unconverted syngas can then be used to fuel a gas turbine for electric power production. The methanol will be used during periods of peak power demand as a supplementary fuel in the gas turbine. Methanol is an ideal gas turbine fuel since it contains no sulfur or nitrogen compounds and has a low tendency to form particulates and nitrogen oxides emissions when combusted.

We plan to submit a proposal for our OTM demonstration project under the recently enacted DOE Clean Coal Technology Program. This demonstration project will draw heavily from the knowledge base that has been developed in the LPMEOH program at LaPorte. Successful completion of this demonstration project should set the stage for commercialization of the LPMEOH technology.

Concluding Remarks

In conclusion let me enumerate several reasons why we believe the LPMEOH PDU project merits a concluding year of Federal support:

1. The LPMEOH technology can be used to convert the nation's abundant coal resources into clean methanol fuel, which can replace fuels produced from imported petroleum.

2. LPMEOH combined with IGCC power production provides the electric utility industry with an efficient and environmentally sound way of using abundant reserves of high- sulfur U.S. coals.

3. The program enjoys major private participation, and program sponsors are actively pursuing advancement of the technology to demonstration and commercialization.

4. From the inception of the program through FY 1986, the DOE has invested $21.5 million and the private sponsors an additional $3.5 million. The final investment of an additional $5.4 million by DOE and $700 thousand by the sponsors will ensure that the project is successfully completed and position the technology for the next step toward commercialization.

Air Products sincerely appreciates the support that our project has enjoyed from this committee. The Federal Government has played an invaluable role in the development of the LPMEOH technology from the laboratory bench scale to the 5-tons-per-day PDU scale. We now hope that this project will receive continued support in its concluding phase.

Thank you for your interest and the opportunity to testify today.

0385G-IA

Statement of

Ying-Chu Lin (Susan) Wu, Ph.D.
Professor of Aerospace Engineering and
Administrator of Energy Conversion R & D Programs
The University of Tennessee Space Institute
Tullahoma, Tennessee 37388-8897

Submitted to

The Committee on Science and Technology
Subcommittee on Energy Development and Applications
U. S. House of Representatives

March 4, 1986

TESTIMONY

Mr. Chairman and members of the Subcommittee, I am Y. C. L. Susan Wu, Professor of Aerospace Engineering and Administrator of the Energy Conversion Research and Development Programs at The University of Tennessee Space Institute. I appreciate the opportunity to submit this statement for inclusion in the record of this hearing. Your continuing support of the development of technologies, which will enable the United States to fully utilize coal, its most abundant energy source, in an environmentally acceptable manner, is vital to the energy future of America. Continuity is crucial for the development of any technology, energy is not an exception.

The future of our nation depends on continued economic growth for not only the remainder of this century but into the next century and beyond. A stable, secure energy supply is the foundation upon which this economic growth must rest. Clearly, the cornerstone upon which to build a stable, secure energy supply must be coal. Coal represents eighty-two percent of the U.S. fuel energy resources, compared with about six percent for natural gas and oil combined. In the coming decades, the U.S. must expand coal use in the industrial and electric utility sectors. To meet the challenge that we face, it is essential that the United States fully develop the potential of coal to provide the energy necessary for sustained economic growth. However, we continue to face the challenge to utilize our vast coal reserves while simultaneously meeting our Nation's environmental goals.

At the present time, there are only a limited number of options available for achieving major reductions in emissions from coal-fired plants. In the recently released Joint Report of the Special Envoys on Acid Rain, Special Envoys Drew Lewis and William Davis state that, "...we learned something very important about potential solutions to the acid rain problem: At the present time, there are only a limited number of potential avenues for achieving major reductions in acidic air emissions, and they all carry high socio-economic costs." Special Envoy Lewis went on to state that "The acid rain issue has been especially difficult to resolve precisely because proposed solutions must choose from a limited menu of control options." He continued that "The availability of cheaper, more efficient control technologies would improve ability to formulate a national response that is politically and economically acceptable." He concluded by recognizing that "...both the U.S. Department of Energy and the Environmental Protection Agency are managing research programs that are investigating a wide range of different control technologies. Taken together, this research offers the best hope for a long-term solution to the acid rain problem." It is estimated that during the 1980's as much as $350 billion could be consumed by various forms of emission control systems. Unless new, innovative technologies are developed and commercialized, more and more of our resources will be consumed by emission control and reduction efforts into the next century. It is essential that we move away from the costly and inefficient methods currently used by power generation systems and replace them with new advanced technologies that effectively and efficiently reduce emissions. One of the most promising new technologies capable of meeting this goal is magnetohydrodynamics (MHD).

The problem of environmental intrusion by emission from coal-fired power plants cannot be solved simply by imposing stringent regulations on the utility industry. Environmental restrictions without the technology development necessary to meet the restrictions will result in higher electricity cost, increases in imported energy, and devastation of the domestic coal industry. None of these socio-economic costs of environmental protection are acceptable, or necessary.

I would like to discuss briefly how the MHD Steam Combined Cycle Power Plant, when commercialized, would impact the current problems of the electrical power production industry.

First, let me mention sulfur dioxide emissions. Our test results obtained at the Coal Fired Flow Facility (CFFF) and analyses have shown that an MHD plant, operating on Eastern high sulfur coal (averaging 3.3% sulfur) and with the amount of potassium seed needed for electrical conductivity, would emit about 0.36 pounds per million BTU of sulfur dioxide. This is about 30% of the current emission limit for existing power plants, built before promulgation of the New Source Performance Standard (NSPS). If it were decided at some time in the future that additional sulfur dioxide removal was desirable, a minor operational change to increase the potassium seed input rate by about 50% would virtually reduce these sulfur dioxide emission to zero. The cost of this reduced environmental intrusion would be about 0.57 mils/kwh. No other technology for coal conversion has this capability. For MHD plants burning Western Coals with lower initial sulfur contents, the plant would operate in the mode of negligible sulfur dioxide emission with the normal amount of potassium seed (1% potassium by weight in the flue gas).

The other major power plant emission, nitrogen oxides, was once thought to be a major problem for MHD plants because of the high combustion temperatures required. This has turned out happily to not be the case. With the system we have devised and experimentally operated, the conditions of most economic power generation produce nitrogen oxide emissions well below the NSPS limit and, of course, much below the standards for existing plants. Early studies, such as the NSF-managed Energy Conversion Alternatives Study

(ECAS), projected that the furnaces might have to be larger than existing coal power plant furnaces to permit the decomposition of nitrogen oxides. We have now determined that this is not the case with the use of staged combustion and, in fact, that the limiting effect is the time required for the transfer of heat from the combustion gases to the water or steam. Thus the furnace for an MHD system will be the same size for a given rating as a conventional power plant.

We are currently investigating the most economic method of particulate removal from the flue gases. Although more work remains to be done in this field, we are confident that the particulate from an MHD plant, which does tend to be smaller in size than that from a conventional coal-fired power plant, can be economically removed to below the NSPS limits.

In addition to controlling sulfur dioxide and nitrogen oxide emissions without requiring expensive post-combustion pollution control equipment, an MHD-topped combined-cycle plant offers a higher overall efficiency which results in lower carbon dioxide (CO2) emissions which contribute to the 'greenhouse effect' that is beginning to attract the attention of scientists.

Carbon dioxide and waste heat emissions from an MHD-topped coal-fired power plant are reduced from 25 to 50 percent as a result of the higher efficiency, reductions that are accomplished without expensive 'add-on' emission control equipment.

The economics of the MHD Steam Combined Cycle Power Plant have been studied extensively in the past and continue to be studied. The MHD plant is slightly more expensive in initial capital costs but the increased efficiency results in lower fuel costs. At current coal prices the levelized cost of electricity produced is essentially the same as for a current conventional coal plant. If coal prices rise, as they can be expected to do, electricity generated from a MHD power plant becomes more economical.

Because of your leadership and the resulting committed strong support from the Congress, we have been able to continue the research and experimentally determine the lower emissions of MHD systems over the past several years. The particulate collection devices—a fabric filter baghouse and an electrostatic precipitator—have been installed in the CFFF and checked out last year. The preliminary results are very encouraging, however much more research testing is required to determine the most effective and economical method for particulate collection because of the different chemical composition of the ash and much finer size particles.

The University of Tennessee Space Institute, Argonne National Laboratory, Babcock & Wilcox, and Mississippi State University are working together on the heat recovery and seed recovery (HRSR) system to solve both the environmental and materials problems. It is essential to operate for long durations to obtain meaningful results on material corrosion and erosion. This work has just been initiated. Work needs to be initiated on seed regeneration to permit processing potassium sulfate to sulfur free compound, and on conceptual design of a retrofit system as outlined in the DOE transition plan submitted to the Congress in June 1984.

MHD is the 'high tech' of coal technology research and development. Completion of the Research and Development phase of MHD technology development has been planned by the Department of Energy and submitted to the Congress in June, 1984. The government-owned research facilities required to complete this critical research are completed and operational. The highly skilled teams of scientists and engineers are assembled and working. The Federal government has supported this program for many years. The end is now in sight. Now is the time to make a commitment to complete the Federal role in the research portion of the program and permit the private sector to then commercialize the technology. Substantial commitments exist from the private sector to carry on the commercialization of MHD if the research phase is completed. Increased environmental concern over emissions from coal-fired power plants is evident both within the United States and with other Nations, as evidenced by the continuing strain on our international relations with our good neighbor and loyal ally to the North, Canada. In light of this increased concern, it is more important than ever that you continue your strong support for this vital technology.

I want to take this opportunity to thank you, the committee members and your able staff for providing the support in the past and plead for continued support to assure the successful development of the MHD technology.

STATEMENT OF

JOSEPH A. MCELWAIN, CHAIRMAN OF THE BOARD
MHD DEVELOPMENT CORPORATION
BUTTE, MONTANA

TO THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
4 MARCH, 1986

My name is Joseph A. McElwain. I am Chairman of the Board of the MHD Development Corporation. Recently, I retired as Chairman and Chief Executive Officer of the Montana Power Company. The primary purpose of the MHD Development Corporation is to initiate, promote, and coordinate efforts to commercialize the technology of magnetohydrodynamics. Charter member companies committed to this corporation are:

- Avco Research Laboratory, Inc.
- Babcock and Wilcox, Inc.
- General Dynamics Corporation
- Gilbert/Commonwealth, Inc.
- Montana Energy Research and Development Institute
- The Montana Power Company
- MSE, Inc.
- TRW, Inc.
- Westinghouse Electric Company

These companies and I have confidence in MHD.

The MHD Development Corporation participated in and supported the formulation and implementation of the multiyear DOE proof-of-concept program directed toward an MHD repowering project. Repowering will consist of integrating the MHD power generating cycle into an existing power plant. As a result, we will demonstrate sub-scale commercial MHD components as well as enable the host power plant to produce more power with the same fuel consumption. The MHD Development Corporation has exhibited its faith in the proof-of-concept and the subsequent repowering project by these actions:

0 Expanded the membership of MHD Development Corporation's Technical Advisory Committee to include DOE's other major MHD test facility operated by the University of Tennessee Space Institute (Tullahoma, TN); the Electric Power Research Institute (EPRI); and additional utilities, such as Arizona Public Service Co., Houston Power and Light, Pacific Gas and Electric, Pennsylvania Power and Light. In addition to the charter companies all these companies are committed to, and believe in MHD.

- o Made available through the Montana Power Company its Frank Bird Power Plant as the host plant for repowering.
- o Submitted a response to the DOE's Program Announcement requesting Information Regarding Emerging Clean Coal Technologies. The response centered on the repowering of the Bird plant.
- o Presented an invited paper to the MHD International Liaison Group Workshop on Retrofit in Rome, Italy on January 28, 1986.
- o Committed to 50% cost sharing by the Corporation with the Government for the repowering project.

The above actions prove industry is serious about MHD, but it must have a partner in this stage of MHD development, a reliable partner: the Federal Government.

DOE's multiyear program design to retrofit a demonstration plant, which DOE presented to Congress in June, 1984, is a good program and an essential program if MHD is to become commercalized. The ramifications of dropping this program will affect many areas beyond MHD power generation. The nations's energy independence program, its credibility in high technology development and the Government's credibility as a partner in any cost-sharing venture are all at stake. It is encumbent on the Federal Government to prove itself as a reliable partner and provide the multiyear funds necessary to proceed through proof-of-concept into commercialization. A multiyear program directed towards the retrofit is essential. A return to the five-year plan proposed by the DOE in their 1985 budget presentations is needed. A five-year program alone, without adequate funding, would not achieve the goals required. Adequate funding would be approximately $40 million a year accompanied by a firm and reliable Government policy to bring the proof-of-concept program to fruition. The start-stop policies of the past have minimized the effectiveness of the monies spent. The history of MHD does not give anyone confidence in the Federal Government as a reliable partner in developing energy systems.

Industry has contributed over $[illegible]0 million to the development of MHD and can be expected to continue to contribute during the proof-of-concept program. In fact, the new, 10% cost-sharing requirements for FY86 will be met by actions already taken by the MHD industrial community. This industrial financial support was either accomplished or planned prior to the cost-share requirement being levied. Industry will continue to provide cost sharing for the advancement of MHD technology, and we believe that the escalating cost-share requirements in future years can be met. However, industry's committment to the Federal Government's proof-of-concept program requires a two-way commitment. The amount that will be contributed will depend upon Industry's perception of how serious the Government, and particularly the Administration, is regarding the continuation of the MHD program.

It is clear that coal must assume an increasing portion of our national fuel mix. We all know coal energy technology is a more viable option at this time than nuclear energy. But we have not been developing this critical area. Looking just a few years into the future, the best forecasts indicate that the demand for electricity will escalate 114% by the turn of the century because electricity is that blessedly versatile form of energy that can serve many needs. Coal could and should be used to generate more than two thirds of our total electricity, assuming attractive economics and superior technology.

Yet, without MHD, coal cannot assume its place in our energy mix. Only with the massive gains in efficiency, economics and environmental control offered by MHD can coal play its assigned part in the shift from primary reliance on shrinking oil suppliers to our relatively abundant coal reserve. Prolonging the life of our coal supply through the efficiencies of MHD suggests that we should follow a course that will bring about expeditious application of this high pay-off technology.

From the perspective of coal utilization, MHD presents the only direct coal-conversion technology on the scene today that increases efficiency as well as meets environmental standards and goals. MHD can utilize all coals, both low and high sulfur.

In summary, I urge adequate financial support of MHD as a technology whose long-term promise transcends parochial interests and the immediate Federal commitment to a broad range of budgetary stringencies. MHD offers our nation, its utility customers and its utilities exceptional opportunities to replace dwindling oil reserves with coal in our total energy mix; to conserve our lone, abundant energy resource by making the most efficient possible use of coal; to burn coal in the most enviornmentally acceptable, efficient manner; to facilitate the ability of utilities to meet national energy goals; and to offer the user of electricity hope that genuine progress is being made to combat the escalation of the price of that energy form. I believe continued support for MHD is imperative in the context of national interest. In conclusion, let me repeat: MHD has been funded for the past several years at $30 million or less, which is the absolute minimum needed to make meaningful progress. To achieve adequate progress in the proof-of-concept phase, $40 million is required annually. Thank you for your attention and consideration.

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

COMMITTEE ON SCIENCE AND TECHNOLOGY

TESTIMONY OF

JACK SHERICK, PRESIDENT AND GENERAL MANAGER, MSE, INC.

4 MARCH, 1986

I am Jack Sherick, President of MSE, Inc., the operating contractor of the DOE-owned, contractor-operated Component Development and Integration Test Facility (CDIF), in Butte, Montana. The CDIF is the largest magnetohydrodynamics (MHD) test facility in the United States, and the largest coal-fired MHD facility in the world. (The USSR has a bigger facility and is building one twice that size, but both USSR facilities are gas-fired.)

The people of Butte have had a reputation for productivity and last year was no exception. Previously, our productivity was exhibited in the field of mining, primarily copper, and now, Butte is exhibiting a similar productivity in the MHD field. We at the CDIF have achieved significant technological accomplishments. I am proud of the progress that we have made and appreciate the opportunity to report positive results to this subcommittee.

In June, 1984 DOE, in concert with industry, developed a five-year program to achieve MHD Proof of Concept, which would provide the information and confidence to proceed a MHD repowering project (the addition of an MHD cycle to an existing power plant). This carefully considered proof-of-concept testing program provides an orderly development of a technology that DOE has characterized as a high-risk, but high pay-back, clean coal technology. There is risk, as there always is, with a technology that can provide a significant improvement in fossil fuel use, particularily the use of coal. The potential of high pay-back is dramatically shown by the calculated savings in fuel costs alone that could accrue over the lifetime of two, just two, first-generation, coal-fired MHD power plants. These savings would pay DOE's total cost in developing coal-fired MHD technology. In addition to cost savings, MHD can significantly reduce the potential for acid rain through increasing efficiency of power production and through reducing sulfur oxides (SO_x) and nitrogen oxides (NO_x).

Proof-of-concept testing is progressing; although in FY85 and 86, MHD funding was more frugal than necessary to continue progress as planned. The reduced budget has not allowed major component spares or newly designed power train components. Testing has progressed by carefully using existing hardware, thorough maintenance, and innovative upgrades to improve performance. Since October 1984, the CDIF's contributions to the advancement of MHD technology have included the following:

- Characterization testing of the TRW-supplied $50MW_t$ coal-fired combustor, first stage, was completed.
- Received, installed, and tested the second-stage.
- Performed conductivity and power generation testing on an upgraded AVCO channel, replaced that channel with a second, upgraded channel, and tested that one.
- Achieved two world firsts during channel testing in 1985--the most electric power generated by a coal-fired MHD unit on August 15th--and the first transmittal (via the EPRI-supplied/Westinghouse-fabricated inverter) of coal-fired, MHD-generated electric power onto the electrical grid system of a utility (Montana Power Company) on August 29th.
- Processed nearly 300 tons of coal for testing at the CDIF and for testing the coal fired combustor at TRW in California.
- Procured and installed sulfur oxides (SO_x), nitrogen oxides (NO_x), and carbon monoxide stack monitoring equipment.
- Evaluated and upgraded existing power channels to improve performance and durability.
- Provided on-site maintenance support for the coal-fired combustor.
- Improved plant systems that measure and control the flow of materials, such as coal. An example of an improved instrumentation device is a laser defraction particle size analyzer and a moisture analyzer to more accurately and more quickly determine the characteristics of processed coal and their subsequent effects on test results.

We can measure how much MHD technology has matured by focusing on the highlights of last year's efforts. We have now reached the developmental-engineering stage where the CDIF personnel, with guidance from the manufacturer, are testing, evaluating, upgrading, and retesting the designer and constructor's hardware without costly and time-consuming shuttling of hardware across the country. In addition, we have generated the world's first coal-fired MHD power. Especially noteworthy is our achievement of all the goals projected in our report to this Subcommittee last year.

Next year at the CDIF we plan to test existing and upgraded MHD power train components. Specific objectives are to:

- Determine and evaluate the effects of operating variables upon performance of the coal-fired combustor and the power generating channels.
- Install and test improved methods of material flow, particularily coal; and improve measurement and control of these flows.
- Furnish processed Montana Rosebud county coal for testing at the MHD facility in Tennessee.
- Test and compare the effects of burning Illinois #6 coal on MHD performance.
- Perform duration testing on the MHD power train.
- Provide testing support for vendor-supplied MHD components, which includes on-site maintenance and upgrading if required and as requested and to provide reporting of test results as requested by the suppliers and DOE.

The CDIF's technological production--realizing significant objectives for the advancing of MHD technology and the efforts planned for the next year--supports DOE's proof-of-concept program. Past progress and present testing at the CDIF use existing workhorse MHD test hardware. Near-term plans include additional, upgraded hardware to ensure uninterrupted testing and to allow test results to be reflected in improved test hardware designs. Testing in the final phases of the proof-of-concept must use more advanced hardware to achieve duration testing. The more advanced hardware will be typical of the hardware to be used in the next testing phase, MHD repowering of an existing power plant. Two years of parallel effort--proof-of-concept testing and repowering conceptual design--will be needed to move the MHD program from proof-of-concept to the implementation of MHD repowering. Data from the latter phases of proof-of-concept testing at the CDIF and DOE's other major MHD facility in Tennessee will be used to finalize the repowering design.

We realize near-term and long-range plans for MHD must be tempered by the reality of reduced budgets and across-the-board budget cuts, however, we believe that proof-of-concept objectives can be met. Private industry is already committed to substantial cost-sharing during the MHD repowering phase; however, an additional cost-sharing plan is to be implemented during the proof-of-concept program. Starting in FY86, 10 percent cost sharing has been incorporated into the MHD program. In FY87, there will 20 percent cost sharing with a 5 percent-a-year increase thereafter. Initial data from the private sector shows that FY86's cost-sharing goal of 10 percent has already been exceeded. Although cost-sharing is an additional challenge placed upon the MHD industry, particularly in FY87, cost-sharing goals in future years, appear to be achievable.

We at CDIF believe the technical challenges can be met, and with the continued support of this Subcommittee, the private sector, and DOE, budgetary challenges can be met to ensure MHD commercialization.

Statement of Donald R. Glenn
Vice President

ENERGY RESEARCH CORPORATION

o **Fossil Energy: Fuel Cells**

I am Donald R. Glenn, Vice President of the Energy Research Corporation (ERC), a subsidiary of the St. Joe Minerals Corporation, a Fluor Company. ERC is among the top two U.S. capabilities in the R & D sector dedicated to advancing and manufacturing electro-chemical power production equipment, specifically batteries and fuel cells. I am submitting this statement for the record, to present an update on ERC's recent progress and our views on the DOE R & D Budget for FY 1987.

Before getting into the heart of my statement, I have to preface my remarks with a caution. The civilian energy R & D program appears to be under attack by the Administration once again this year. In assessing the short term energy horizon, it may be convenient to create a case for dramatic, and disproportionate budget reductions (in energy development) from among the R & D agencies. However, there is no doubt that our energy wants, and the supply systems ability to respond to those demands have different time constants. It takes much longer to bring the supply-side energy and new power resources to the marketplace and this does not consider any foreign oil or gas sources and their reliability. In setting your priorities in this fiscal climate, I hope that the other "defense" sensitivity, our energy security, is viewed as the equivalent in our power and industrial "bloodline" as weaponry is to our military.

There's a new twist to our complex energy situation this year due to a series of unrelated events that together form a clear picture of a nearer term energy strategy; first, the issues:

1. Passage of the Gramm-Rudman-Hollings Act.
2. Rising electricity costs in the face of an energy "glut."
3. Confident forecasts of the need for new generation capacity and incorporation of load management systems.
4. The heightening concerns for the effects of acid rain.
5. Ridiculously long lead times to build large nuclear or coal-fired central station power plants and their escalating costs.
6. The Administration's consistent downplay of the DOE's Fossil Energy and Conservation/Renewable R & D programs coupled to an almost hypocritical policy switch from first espousing "long-term, high risk" research to now requiring 50% private sector participation with the government, in concert with competitors in energy systems development activities.

In a strange way, most of these items combine to support two very key ERC technologies seeing excellent progress and successes along the path toward first systems trials by intended commercial interests. The six items (stated above) form a strategy and bring my firm's Direct Fuel Cell program into focus as the subcommittee strives to determine a set of energy R & D priorities and their impacts on the DOE FY 1987 Budget Request

It is certain that the Gramm-Rudman-Hollings Act will press for broad and deep spending cuts in, among other areas, energy R & D. An eventual tax increase will only come after all desperation measures of budget cuts are exhausted. Coupled to the Administration's new FY 1987 Budget which proposes to further stifle technical advances in new energy systems, energy security is clearly not a priority despite foreign oil instability. In light of this, there is a pattern that is emerging that can aid in formulating a rationale for decisions impacting the energy sector. As you know, both oil and natural gas prices have been in decline for some time. Some of the reasons for this is reduced consumption due to a general decrease in heavy industry production, process improvements to non-energy intensive methods, transition from smoke-stack industry dominance to services and electric-driven manufacturing, and infighting among the OPEC nations. Utilities, having been stung by abandoned or lengthy nuclear plant construction projects, and very complicated institutional barriers to siting. As a result, they are moving away from large capital-intensive new plant investment to incremental generation additions and load management techniques to meet their steadily increasing demands.

ERC's answer to this, is our Direct Fuel Cell (DFC) for on-site power and cogeneration in the smaller capacity range (100 to 500 kW) and in dispersed generation systems covering from 1 to 200 MW with coal as the fuel of choice in the larger systems. The DFC can be installed at the utility's site or at the customer's side of the meter, a most attractive option. The system is quiet, essentially non-polluting, offers very low cost electricity, facilitates easy and rapid implacement on virtually any site, and requires very little space. For these reasons, this technology deserves continued Federal support in partnership with the already-committed outside funding by ERC, EPRI and several other firms.

As further evidence of the increased confidence that this program is "on-track," I will review some highlights of recent ERC progress and note results from our efforts to recruit additional private sector support. The program's funding needs are also updated.

Direct Fuel Cell

Fuel cells are known to be more efficient than other conventional generators because they do not have any moving parts and are not Carnot cycle limited. The ERC Direct Fuel Cell (DFC) is the most efficient power generation technology known. The defense of this statement lies in the conversion device's ability to directly process methane-containing fuel gas to electricity (and high quality waste heat at 1150 degrees Fahrenheit). By accepting the gases directly, expensive external equipment and piping are eliminated with the resulting electrical efficiency reaching 60% and higher. ERC's DFC can be fueled by any one, or a combination of, methane or hydrogen-containing sources such as natural gas, biogas, coal-gas and eventually, liquid hydrocarbon fuels with suitable cleanup and pre-treatment. Further, DFC efficiency remains constant from part - through full - load operations, another attractive feature of this technology.

The DFC system will be developed by utilities as baseload dispersed generators, peaking equipment and as stand alone on-site power systems in ranges from 100 kW to over 200 MW with only the Balance-of-Plant equipment changing to capitalize on scalar economies. The fuel cell stacks (the heart of the generation plant) are modular and only increase in numbers to satisfy a user's capacity requirements. Most importantly, the system is non-polluting (even with coal fuel), quiet, and easily and quickly assembled on any available site. In fact, a 2 MW dispersed powerplant needs less than 1/8 acre! Capital costs are estimated at $1330/kW installed.

ERC continues to achieve measurable technical progress in our Direct Fuel Cell (DFC) program. Most notably, we built and successfully tested a 10-cell subscale, short stack incorporating our internal reforming technology and newest component design features. The stack operated for a planned three months fueled directly by natural gas. This is a technological first and most important milestone, demonstrating the DFC ability to convert 100% of the methane in a thermally balanced system.
Other program progress includes:

- Anode creep-resistance verified for required life
- Internal reforming design verified for projected life
- Scale-up of a low-cost ceramic matrix to full scale is in hand

- Advanced, cost-effective bipolar plate tested in multi-cell configuration
- Nickel solubility problems appear close to being resolved in tests now underway

There are no known technical impediments to completing the design of our building block DFC module and the start of full-area short stack testing in the 1987-88 timeframe. To put this into a systems perspective, the stack is the heart of the total powerplant and consists of a sandwich-like assembly of six repetitive components. All remaining balance-of-plant hardware is essentially off the shelf. The Fluor Corporation has been continuously involved in providing economic evaluations and plant designs of the DFC-based powerplant as a dispersed generator. Fluor projects a total installed plant cost of $1,330/kW with the DFC modules representing only 16% of this total. The major portion of the total cost of electricity (COE) is the fuel price paid by the utility at 63% (assuming a fuel cost of $7.75/mmBTU in January 1991). Further, annualized owning and operating costs (as COE) is the lowest of all generation options except for hydropower. The plant will have a heat rate of 6450 BTU/kWh, as compared to 10,500 BTU/kWh for conventional fossil-steam powerplants, a 40% improvement! It is to this aspect that the full benefits of DFC technology can be realized. As a multi-fuel compatible capability, the DFC user can select a gas fuel-natural gas, coal gas, biomass or other methane-containing source, solely on a price or availability basis. After gas cleanup the fuel can be indiscriminately piped to the powerplant's fuel cell modules. Utility and energy planners project that additions to capacity for utility and large industrial uses favors employing fossil-derived gaseous fuels in dispersed generators and for incremental additions to total generation capacities. The DFC offers fuel source selection flexibility, no environmental (noise, pollution) adversity to limit siting, and enhanced efficiency, making this technology premier among the field of choices. In fact, a recent EPRI study[1] shows that a 6450 BTU/kWh generator can capture 88% of the market for utility peaking capacity additions. ERC studies show that DFC power can be generated at a cost of $.05/kWh using coal with no environmental adversity. I'd like to now address the DOE-Fossil Energy budget and guidance for FY 1987.

The Administration, with unfailing consistency, again suggests that molten carbonate cells be short-changed with FY 1987 funding recommended at near close-out levels. We have continued to seek additional research sponsors to our current program as ERC enters the final and most costly phase of this development-stack fabrication, assembly and testing at full scale. I am very pleased to note that some private utilities are expected to join EPRI and ERC in this endeavor to ease our financial dependency. I plan further, more aggressive, contacting to include major industrial interest in the coming year. In the meantime, I ask the Congress to "stay the course" with our promise for sustained and significant continued progress in our DFC advances. Presently, of the two U.S. manufacturing firms in the advanced stages of MCFC technology development, only ERC is wholly U.S.-owned. Japan, our major foreign competitor has seven large companies active in MCFC R & D and fully aware of the lucrative markets ahead. They are planning a multi-year, $250 million

---

1. EPRI Report No. EM-3205, August 1983

program to bring MCFC to commercial maturity. Italy and Holland are also planning multi-million dollar programs. The argument of whether internal or external (conventional) reforming is the best method is a moot point knowing the impact this advanced fuel cell technology will have on our domestic use of fuels to meet the steadily rising demand for electricity. Both efforts should receive adequate funds. We see our DFC approaching a state where a field test of a first building block module continues to remain firm (in late 1988/early 1989), evidence that the ERC work is moving as planned with no new technical "stoppers" noted. We first presented this program plan to DOE and Congress two years ago and believe it remains sound.

In the context of defending promotion of domestic competition, a stated objective by DOE, a more serious issue is that of international competition. In this regard, the American preeminence in providing power generation hardware and powerplants is in serious jeopardy with respect to the MCFC concept. To be penny-wise and dollar foolish at this juncture for this technology, would effectively sever the creation of the best power producer ever conceived and give our markets in this arena to others.

In 1984, ERC defined a 3-year program leading to a full-scale stack test at 50-100 kW by late 1987. The effort was proposed at $15.5 million of which $3.0 million is secured through private sector support. The DOE-portion appropriated (for FY 85/86) is $6.25 million, less 15% "taxed" for DOE-management activities, leaving $5.31 million, or $1.7 million short of the originally proposed ERC R & D effort. Of necessity, ERC has replanned in accordance with these funding variations and has intensified efforts to broaden the private sector interest and attract more support. The good news is that we expect added support from a prominent electric utility. The bad news is that EPRI, our major outside supporter is facing drastic R & D funding reductions due to the poor economic condition of their member companies. The result is a net decrease in the non-government funding for this year. The program has slipped about one year, to the 1988-early 1989 timeframe for the first full DFC scale stack test. The DOE-portion program funding to preserve this new schedule is $5.0 million in FY 1987 and 2.5 million in FY 1988.

I thank the Committee for its strong leadership and most positive support of the Direct Fuel Cell and molten carbonate fuel cell technologies. The rewards for our labors, and the societal benefits, are only a very few years away. I welcome your questions and comments on this and all ERC fuel cell programs.

International Fuel Cells

195 Governors Highway
P.O. Box 739
South Windsor
Connecticut 06074

March 10, 1986

The Honorable Don Fuqua
Chairman, House Science and
Technology Committee
Room B374
Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Fuqua:

Enclosed is testimony submitted by the International Fuel Cells Corporation for your consideration in preparing authorizing legislation for Fiscal Year 1987.

International Fuel Cells deeply appreciates your past support and asks that you give careful consideration to our request for Fiscal Year 1987.

Sincerely,

Bill Podolny
William H. Podolny
Chairman, International Fuel Cells

Facsimile (203) 727 2319 TWX 710 425 0137 Telex 681 3166

Testimony of

William H. Podolny

Chairman

International Fuel Cells Corporation

Mr. Chairman, I appreciate the opportunity to testify before your committee. As the Chairman of International Fuel Cells Corporation, I represent an entity which is an affiliate of United Technologies Corporation. This entity was incorporated in 1985 to fulfill a commitment to this committee, the Congress and the federal government. International Fuel Cells Corporation, IFC, has been organized and is operating with the sole objective of developing a commercial fuel cell power plant. The word "commercialization" is sometimes used freely and haphazardly in conversation and publications concerning the end point of research and development efforts. In the real world, however, such words require precise definition when considering the level of resources that must be placed at risk. It is not the purpose of this testimony to develop definitions and criterion for commercialization of fuel cell power plants. Suffice it to say, that before there can be a continuing business success; a manufacturer, offering competitive equipment on a continuing basis, must identify a customer willing to buy and use such equipment because it is beneficial to his business. There is, however, an intermediate step where either the manufacturer or the customer, or both, assume a nonprofitable risk position. During this exposure, there must be confirmation of the critical aspects of economic viability on both sides.

IFC investors have agreed to an initial product and market development investment as a demonstration of integrity of purpose for the world's first commercial configuration of an electric utility power plant. Investment is being made as a demonstration of purpose that permits IFC to go forward to the electric utility industry. IFC is soliciting sales commitments from electric utility companies for an initial lot of power plants. This will permit the evaluation of the product by the electric utility industry in such a way that a clear determination of future markets can be established. This will allow evaluation of the manufacturing process and the product to confirm the prospectus for achieving competitive first costs and competitive operation costs.

IFC has established a limit to the loss it could incur if the venture fails as its contribution towards the commercialization process. In our petition to the electric utility industry for sales commitments, we are assuming a certain degree of potential loss by the electric utility companies if the initial equipment fails to live up to expectations and promises. IFC's commitment to a potential loss is a demonstration of integrity designed to encourage the utilities to consider participation and potential exposure. The most critical element of the commercialization process is to provide the electric utility companies with confidence that their potential loss will be minimal and that their potential future benefits will be high.

IFC is dedicating all of its available resources at high risk to the specifics of the product and market development. The greatest single contribution that the federal government can make, as part of its long time engagement in the evaluation and development of the technology, is to continue the support of technology improvements that could provide the basis for a successful evaluation and the basis for clearly meeting competitive initial and operating cost requirements in future deliveries.

Normally, it takes 15-20 years for the utility industry to accept the viability of a new generating technology. In the case of the fuel cell, the evaluation process must be accelerated to establish the economic and commercial viability of the fuel cell power plant before 1992-1993. It is during this time frame, that the electric utility industry will add substantial generating capacity. It is for that reason that despite our recognition of the need for budgetary restraint, we cannot agree with the Administration's position concerning the Department of Energy's recommendation to defer the FY 1986 appropriation and its budget request for FY 1987.

The private sector, which includes this manufacturer, individual electric utilities and gas utilities and their respective research institutions, have made major continuing investments in this technology area since 1965. The federal government has supported specific activities that this company and its predecessor have been responsible for since 1975. More dramatically, however, in the last 3 or 4 years as we gained momentum and improved the prospects for commercial viability, our program results have been truly impressive. As mentioned above, the creation of IFC is also a result of the successful program.

The federally supported programs, which also include private sector investments, led to the very successful results of the 4.5MW electric utility fuel cell power plant demonstration program in New York and Tokyo. All of the technical and operating features: power level, emissions, response rate, automatic operation, short lead time, environmental site acceptance, noise, etc., were established with little or no discount from the objectives. Specifically, the demonstration plant operated for almost 3,000 hours and generated 5.4 million kilowatt hours of power. The concurrent improvement in the various technologies to achieve superior performance, cost, durability, and reliability in full scale componentry, together with advanced systems concepts, provided the foundation to undertake the IFC product venture risk.

Simultaneously, the gas industry has pursued a federal and privately funded program to establish the operational viability of the on-site fuel cell power plant based on the comprehensive field test using a 40KW experimental fuel cell power plant. This program was an outstanding demonstration of advanced technologies, research and development. More than 40 power plants in the hands of some 35 utility companies together with a handful of Dept. of Defense and industrial installations achieved on the order of 270,000 hours of operation to date with the relatively extraordinary gross average availability of 65-67%.

Electrical efficiency, energy efficiency, isolated load following operation, grid-connect operation, co-generation, computer reliability, power demonstrations, parallel operation with multiple units and extremes in climate and physical location were all part of the test and all successfully demonstrated. A parallel program to establish advanced systems, improve performance, lower costs, strengthen reliability, increase durability and endurance by research and development in advanced technologies were so successful that it has established a basis for IFC to announce, together with the gas utility industry, its plans to go forward with a second commercial fuel cell product venture, i.e., a 200 KW on-site fuel cell power plant with initial delivery starting in mid 1990. That product venture will differ somewhat from the electric utility product venture in that the investment in the product development will depend upon obtaining a significant number of initial commitments from the gas utility customers.

In addition, there have been advances in molten carbonate technology and there have been identified advances in phosphoric acid technology which establish a stronger basis for fuel cell power plants becoming amenable to operation on gasified coal, whether integrated or not. Efforts to improve componentry and system elements to make such fuel economically viable for fuel cell power plants for a bona fide technology program are deserving of support.

IFC recommends the following levels of funding for specific IFC programs in Fiscal Year 1987:

1) 11 MW, water-cooled, phosphoric acid technology development program - $7 million;

2) on-site technology development program - $3 million;

3) molton carbonate technology development (complete technology development initiated by FY 1986 funds and initiate full height stack demonstration program) - $4 million; and

4) solid oxide (money to initiate a planer solid oxide cell configuration) - $1 million.

###

The Consortium for Fossil Fuel Liquefaction Science

Making coal liquefaction an energy resource alternative

Members

University of Kentucky
University of Utah
University of Pittsburgh
West Virginia University
Syracuse University
Kentucky Energy Cabinet

March 3, 1986

RECEIVED
MAR 13 1986
COMMITTEE ON SCIENCE
AND TECHNOLOGY

The Honorable Don Fuqua, Chairman
Committee on Science and Technology
2269 Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Fuqua:

Attached is a brief statement on the FY87 DOE budget request that we ask be included in the record of the Energy Development and Applications Subcommittee. As the state with the highest annual coal production, Kentucky has a strong interest in maintaining an adequate coal research program. If accepted as is, the proposed Department of Energy's FY87 requested coal budget authority would do long-term harm to the coal research effort of the United States. Obviously, we cannot afford to do this considering the fact that coal comprises by far the largest part of our fossil energy reserves.

As a representative of the Consortium for Fossil Fuel Liquefaction Science, I am particularly concerned that the federal government's already limited involvement in long-term coal liquefaction research is being decreased rapidly. We should not allow cheap oil to lull us into complacency about planning for our future liquid fuels needs. If economically efficient novel coal liquefaction technologies are to be in-place when needed sometime in the not-too-distant future, the groundwork must be laid now by continuing our research efforts. Consistent with the effort to trim the federal budget deficit, I hope that your committee will be able to restore as much of last year's coal research funding level as possible.

Thank you for your attention and should you need any further information, I would be happy to oblige.

Sincerely,

Lyle V.A. Sendlein, Director
Institute for Mining and
Minerals Research,
University of Kentucky

Attachment

MAR 13 1986

University of Kentucky, 12 Porter Building, Lexington, Kentucky 40506-0205 (606) 257-8636

Statement of

Lyle V.A. Sendlein
Director, Institute for Mining and Minerals Research
University of Kentucky

on behalf of

the Consortium for Fossil Fuel Liquefaction Science

submitted to the

House Committee on Science and Technology
Energy Development and Applications Subcommittee

The price of oil is falling to levels not seen in several years. For the nation as a whole, the decline in the price of oil provides strong economic benefits. Unfortunately, as the price of oil declines, the complacency about planning for our energy future increases. That complacency is reflected in the FY87 Department of Energy Fossil Energy budget request. The new budget authority requested for FY87 is well less than one-third of last year's appropriation. The FY87 budget authority requested for coal research, including carryover funds from proposed FY86 deferrals, is one-third of last year's appropriation. When we consider the size of our coal reserves and their long-term importance, it is difficult to understand why we would drastically reduce our efforts to better utilize those reserves. We must learn from our previous decision in the 1950's to reduce our coal research budget to such a point that we could not develop the knowledge that would have helped in the 1970's. Basic research into coal liquefaction was needed then and is even more necessary today. The Congress is to be commended for its appropriations for the Clean Coal Technology Program but we need to continue the more basic research that will lead to even better coal utilization programs further down the road.

Our purpose is not to attempt to lobby the Congress for huge increases in coal research funding. The need for such an increase is welljustified but the need to reduce the federal budget deficit makes such an increase fiscally and politically difficult. We do ask that the Committee maintain as much of the FY86 authority as possible by resisting the draconian cuts proposed for FY87. Specifically, the coal liquefaction program is already bare-bones. Reducing it by anything close to the over 70 percent cut recommended by the administration would do long-term harm to the coal liquefaction research effort of this country.

The need for a long-term coal liquefaction research effort is clear. Even with the rapid increase in domestic oil drilling activity brought about by oil shortages and price increases, the United States continues to use its oil faster than we can find it. Petroleum imports are increasing and, according to the Energy Information Administration, could account for half of the United States' oil consumption within a decade. The United States could deplete its recoverable oil reserves within a few decades and will be vulnerable to oil supply shortfalls in the meantime. It is important that the U.S. continue to make preparations now for a future of declining and unstable oil supply.

The recent demise of the Synthetic Fuels Corporation was a function of several factors but our scientific and technological ignorance was the most serious and falling oil prices provided the coup de grace. The rationale behind the Consortium for Fossil Fuel Liquefaction Science is that we can learn from the problems of the SFC and ensure a more successful synthetic fuels industry when it is needed in the future. Considering that much of our energy infrastructure is based upon liquid fossil fuels, our need for such fuels will only diminish somewhat as our domestic petroleum supplies become scarcer and are eventually exhausted. By maintaining a strong liquefaction research base now, while petroleum is relatively plentiful and moderately-priced, we can develop environmentally sound, economically and technologically efficient liquefaction technologies to be implemented when needed.

The Consortium for Fossil Fuel Liquefaction Science was formed by the University of Kentucky, the University of Utah, the Kentucky Energy Cabinet, the University of Pittsburgh, West Virginia University, and Syracuse University to pursue long-term research that could lead to new, efficient coal liquefaction technologies. The Consortium, by its cooperative nature and core of nonfederal support, is able to make efficient use of the limited federal funds made available for such research. If the Consortium can continue to receive temporary federal support, we can build and maintain the research infrastructure needed to continue a base-level research program into novel coal liquefaction technologies.

The organization of the Consortium is designed to maximize the strengths of the participating institutions and provide for the development of a structure that limits duplication and focuses effort. Organized around three program areas, the Consortium conducts research, evaluates the liquefaction potential of U.S. coals, and assesses the full range of technological alternatives for the production of synthetic liquid fuels. Through these program elements, the Consortium will be capable of maintaining an active role not only in research, but also in determining the factors that can best lead to the development of an efficient synthetic liquids industry when it is needed in the future.

The Consortium is pursuing several projects to achieve its goals. A project at the University of Pittsburgh involves direct coal liquefaction utilizing plentiful heavy oils and petroleum residuals. We are beginning to understand how coal, when co-processed with them, prevents the normal coking of heavy oils and residuals at high temperatures. The ultimate result of this research will be a technology base--for all coals and heavy oils--for understanding what occurs during co-processing. Another promising technology, differential liquefaction, is being developed at the University of Utah. Utah scientists have demonstrated that microscale pyrolysis tests produce the same product slate as that found in both Lurgi and Wellman Galusha gasifier-produced pyrolysis tars. The detailed analytical work carried out on the pyrolysis tars coupled with computerized multivariate factor analysis has demonstrated that a very high quality hydrocarbon product is produced. The pyrolysis char is of high quality and has been demonstrated in a commerical power plant to be a highly desirable boiler fuel. The economics of producing a high quality pyrolysis tar and a useable char are very encouraging. At the University of Kentucky, a coupled, two-phase research effort aimed at developing biologically-enhanced coal liquefaction and improving hydrogenation during direct liquefaction is being pursued. Microbial removal of organic sulfur and nitrogen, and inorganic sulfur by acclimated microorganisms at pH near 3 should enhance liquefaction behavior. West Virginia University is developing a novel technique for the dissolution and separation of liquid fuels from bituminous coals utilizing a relatively unexplored class of solvents, the so-called "supersolvents." The use of inverting or "antisolvents" to achieve efficient recovery of the solvent from the liquid and solid products is being emphasized. New methods are being explored to develop a low-temperature liquefaction process by using supersolvents and employing CO and H_2O with transition metal catalysts as reductants. The Kentucky Energy Cabinet's research laboratory is systematically evaluating the relationship between basic process characteristics of feedstock resources and their subsequent behavior under various liquefaction processes. The effort will generate a substantial data base to be made available to the liquefaction technology industry and should provide companies with the data to make an assessment of the liquefaction potential of a full range of feedstock resources. Syracuse University is developing a technological assessment of the role future coal liquefaction technologies will play in the future energy market.

To summarize, we cannot as a nation possessing tremendous coal reserves afford not to develop technologies to better utilize them. The fate of the Synthetic Fuels Corporation taught us that the time for wide-spread synthetic fuels development is not yet at hand. The need for a such an industry will arise in the not-too-distant future. The maintenance of a sound research program now and over the years will greatly increase the chances for the development of an efficient industry, which will benefit both the economy and the security of the United States. Since DOE's coal research program is small to begin with, we feel it is prudent and fair that the Committee and Congress sustain it at close to current levels and we urge you to do so.

WRITTEN STATEMENT

by

Dr. C. Everett Brett, Director

Natural Resources Center

The School of Mines and Energy Development

The University of Alabama

to the

Subcommittee on Energy Development and Applications

House Committee on Science and Technology

Hearings on Fiscal Year 1987 Authorization for the

Department of Energy Thermal Energy Storage Programs

March 3, 1986

This statement pertains to FY 1987 Department of Energy R & D Appropriations for Thermal Energy Storage Research. The University of Alabama strongly endorses the continuation of thermal energy storage research at a modest level of funding and offers recommendations whereby an effective R & D program can be continued at a funding level below that appropriated to The Department of Energy in FY 1986.

The Natural Resources Center at the University of Alabama has been responsible for alternative energy and environmental research since 1969 and as a division of the School of Mines and Energy Development since 1978. The Natural Resources Center develops, conducts, and supports alternative energy and environmental research which responds to state, regional, and national needs. To accomplish these goals, the University of Alabama for many years has committed substantial funds and human resources to research directed at finding ways of reducing the use of and conserving the nation's energy resources and reducing the environmental impact of producing energy. The Natural Resources Center in cooperation with the Department of Mechanical Engineering has been conducting research in thermal energy storage in aquifers since 1977.

Thermal energy can be stored in aquifers either as heat for winter heating or as chill for summer air conditioning. Significant attention has been given by the Department of Energy since 1976 to the storage of hot water in aquifers for heat recovery on an annual cycle. Less attention has been given to the prospect of storing cold water generated in the winter time for summer air conditioning. The Natural Resources Center has concentrated its efforts on research pertaining to the storage of chilled water for air conditioning because of the high electrical energy demands for air conditioning in the South. Air conditioning occurs the year around in large buildings, even in the cold northern latitudes of Canada because of the internal loads generated by large major buildings. Aquifer air conditioning consists primarily of pumping water in the winter time from an aquifer from one set of wells and cooling it by exposure to cold air temperatures and returning it to the aquifer in a second set of wells. Flow between the two sets of wells creates a storage volume that contains the chilled water on an annual cycle. In summer, the flow is reversed and the chilled water is pumped back to the surface and used for air conditioning buildings. After the water passes through a building and is warmed, it is pumped back into the original set of wells and the cycle is subsequently reversed. Our results through theoretical modelling and through experience with a prototype air conditioning systems constructed in the Parisian Department store in Tuscaloosa, Alabama, and in the University of Alabama Student Recreation Center show that a minimum of 50% of the air conditioning energy and cost can be saved as compared to conventional electrical air conditioning systems. The cost of purchasing and operating expensive chillers is eliminated. The main components of the system are the cooling towers or cooling ponds used to chill water, the wells, pumps, the connecting piping, the aquifer itself, and controls to operate the system. Our studies show further that in some systems as much as 80% of the cost of electricity and energy can be eliminated, and that 70% of the nation's population is located in areas where aquifers are available for thermal storage.

In addition to the aquifer air conditioning systems constructed for Parisian Department Store and the University of Alabama Student Recreation Center, a system has been designed by the University for the General Motors Rochester Carburetor Plant in Tuscaloosa for which bids have been received. The front end costs as indicated by the bids show a payback of 6 years. Currently, the project is in a holding status because General Motors has a payback limitation of 4 years for all energy conservation systems. The system has since been redesigned incorporating the experience gained in the original design and a three to four year payback is expected for the new design. However, General Motors Corporation, although it has encumbered funds to build the system (700 tons @ $250,000), is reluctant to go forward with the construction unless the Department of Energy is willing to participate in a monitoring program to evaluate the operational effectiveness of the system. They feel there is too much risk to build the system without a means of evaluating its operation. Should the system prove effective, as anticipated, General Motors Corporation has indicated that they would have a strong interest in using this energy conserving technology throughout their industry. This would be an outstanding opportunity for joint federal and private enterprise research.

The aquifer air conditioning systems at the Parisian Department Store and at the University of Alabama Student Recreation Center were constructed without federal funds. The system at the General Motors Carburetor Plant would also be constructed solely from private industry resources.

In the late 1970's DOE constructed a large aquifer air conditioning system in New York which ultimately proved to be a failure. Because the Parisian system worked, DOE invested a modest sum of money for monitoring the system. During the course of this monitoring the Student Recreation Center System was constructed and has been operating successfully for over three years without serious problems. DOE is currently investing a modest sum in monitoring the Student Recreation Center but at a level that limits the amount of information that can be gained. The University took some risk to construct this system, and now we are learning why it is effective when earlier systems have failed. We now know that the systems will work and that the cost savings are real, and we are continuing to develop designs that minimize front-end costs for construction to make the payback increasingly attractive to industry.

In addition to the aquifer air conditioning system just described the Veterans Administration Hospital in Tuscaloosa is planning the renovation of several of its buildings. This renovation includes energy conservation renovation and is planned to include aquifer air conditioning as part of the work. These plans have been reviewed by the Veterans Administration Engineering Division in the Washington D.C. central office and have been conceptually approved for the Tuscaloosa site. This would be an ideal site to demonstrate the commercial application of aquifer air conditioning because of the benefits that would accrue to the Veterans Administration and because, in this particular case, four of the treatment buildings would be incorporated into a single system with the storage volume located in a large rectangular area between the four buildings. It would be very beneficial for the Seasonal Storage Program in the Department of Energy to monitor this new system at the Veterans Administration Hospital because it would be a fourth generation design benefiting from the design experience at the General Motors Carburetor Plant. We are reluctant to go forward with the Veteran's Administration System, however, without having learned from the construction of the system at the General Motors Carburetor Plant. Although the Veterans Administration could tolerate a 6-year payback for the construction of their system, it is probable that a system with as low as a three or four year payback could be designed based on criteria learned from the General Motors Carburetor Plant.

The future of aquifer air conditioning and the large benefits that can accrue from this commercial energy savings strategy depends on progress developed at the General Motors Carburetor Plant in Tuscaloosa. A successful experience at this plant could result in the construction of aquifer air conditioning systems throughout the General Motors organization and similar installations at federal facilities such as VA Hospitals, military bases, and other large federal installations which could significantly reduce the government's energy bill.

In spite of the significant potential for thermal storage to conserve energy on a national basis, the Department of Energy has reduced funding in this area in preference to other programs. These funding reductions have been the result of total program reduction in recent years. For instance, in FY 1981, Thermal and Mechanical Storage (now Thermal Storage) received

23.6 million dollars and the Batteries program received 27.3 million dollars. By FY 1985, Thermal Storage received 2.3 million while the Batteries Program received 16.8 million. Subsequently, DOE recommended termination of the Thermal Storage Program.

Large sums of money have been expended to produce minor improvements in some chemical battery systems as compared to progress made in Thermal Storage. Research in Seasonal Storage, particularily cold water storage in aquifers for air conditioning, has made some large strides on very limited funding. Most of this funding has come either from private enterprise or state sources. So far, only $100,000 has been committed to the current study of cold water storage in aquifers for air conditioning. This is to monitor the system at the University of Alabama Student Recreation Center which was constructed at no cost to the government. Already, results from this system is providing information which could make the application commercial in two to three years. However, there are still too many unknowns, and enough risk to keep the technology from being attractive for commercial application.

The applications of aquifer air conditioning are economically limited to a minimum of about 150 tons. Since the application is suited primarily for very large installations such as hospitals, factories, and major buildings, the savings of natural resources through the reduction of energy usage and the cost savings to commercial users is very large. Although we have some experience in operating these systems at the Parians store in Tuscaloosa and at the University Student Recreation Center, and know that they will work, and that the savings are real, we are still learning how to design a system at the minimum front-end cost for construction to make the payback more attractive to industry.

In addition the technology will have the effect of reducing the total demand for electricity, thus limiting the need for new electrical generating equipment and potentially limiting environmental degradation caused by generating electricity (acid rain, etc.). It also load-levels by shifting the demand for electricity for air conditioning from summer to winter.

Before making a recommendation for FY 1987 funding, the funding for FY 1986 should be reviewed. In FY 1986, Congress appropriated $7 million for Thermal Storage in the language of the bill. However, the appropriation tables showed $3 million for Thermal Storage. DOE elected to ignore the $7 million appropriation in the language and chose to commit $3 million as reflected in the tables. Of the #3 million dollars, only $1.6 million was actually committed to Thermal Storage. The $1.6 million was distributed as follows:

Industrial Storage - $300,000 ORNL
Diernal Storage - $700,000 ORNL
Seasonal Storage - $600,000 PNL

The remaining $1.4 million of the $3 million appropriation was assigned to:

Hydrogen - $1,000,000
Solar Thermal - $200,000 SERI
Tax - $200,000

Hydrogen manufacture and solar thermal research is only marginally related to thermal storage research.

Even though the Department of Energy chose to ignore the $7 million appropriated in the language of the bill, that level provides a modest funding for support of a viable Thermal Energy Storage Program. With the problems confronting Congress relative to the national deficit and passage of the Gramm/Rudman/Hollings Act, we recommend a FY 1987 Thermal Storage budget of $6 million: this is 85% of the FY 1986 budget as appropriated by Congress in the language of the bill. Even though the program is currently being maintained at essentially a $1.6 million level, the recommended level will maintain a steady rate of progress toward the development of a strong technological base and commercialization of the technology which promises a very high energy conservation potential. A core program can be maintained if appropriate adjustments are made which can show significant progress on an annual basis. We recommend the following specific programs for Thermal Energy Storage:

Industrial Storage - $2.5 million ORNL
Seasonal Storage - $2 million PNL
Diurnal Storage - $1.5 million ORNL

These recommendations, although reduced, are in keeping with the levels appropriated by Congress for FY 1986.

The University of Alabama has been deeply involved in improving our research base in thermal energy storage; hence, we offer our thoughts regarding the priorities for Thermal Energy Storage research as a national program. In addition to our own laboratory and field research efforts, we continuously monitor activities relating to other technologies, research findings, environmental concerns and economic factors that impact the utilization and commercialization of thermal storage technology. We acknowledge that the University has a vested interest in the Thermal Energy Storage Program as described above since we have already made so much progress without federal support. We consider the development of this technology as essential to national energy conservation. The University is not directly involved in the Industrial or Diurnal Storage programs conducted at Oak Ridge National Laboratory, but both programs are extremely important to energy storage and the future of energy efficiency development in the United States. The Industrial Storage Program is working with near-commercial technology to capture waste heat and recycle it in manuacturing processes. As you know, the United States Industries are among the most inefficient in the world, and part of their inability to compete worldwide is their high cost for energy. An example is the heat loss in kilns (brick, wood, etc.), foundries, and other large heat demand industries. We are also very impressed with research strides that have been made with Diurnal Energy Storage which involves the load leveling strategies such as generating ice at night for daytime air conditioning. Much of the diurnal technology is being applied commercially but many new strategies need to be developed and evaluated in this area.

The University of Alabama through the School of Mines and Energy Development and the College of Engineering strongly endorses continued funding of the Thermal Storage Research Program especially in the areas of Industrial Storage, Seasonal Storage, and Diurnal Storage, and urges the appropriation of a very modest $6 million for its continuation in FY 1987.

APPENDIX

Additional Materials for the Record

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

CLEAN COAL TECHNOLOGY

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

NAVAL PETROLEUM AND OIL SHALE RESERVES

VOLUME 6

TABLE OF CONTENTS

Summary of Estimates by Appropriation 3

Summary of Staffing by Subcommittee 5

Summary of Staffing by Appropriation 6

Clean Coal Technology 7

Fossil Energy Research and Development 13

Naval Petroleum and Oil Shale Reserves 143

Department of Energy
FY 1987 CONGRESSIONAL BUDGET
MAJOR ACTIVITY OVERVIEW

Clean Coal Technology Program

Background

Coal is the most abundant energy resource in the United States with recoverable reserves estimated to be 935 billion barrels crude oil equivalent (COE). However, petroleum and natural gas, whose proven reserves are estimated to be 28 billion barrels and 35 billion barrels COE respectively, are the most utilized fossil fuels in the U.S. energy consuming marketplace despite their significantly higher costs relative to coal. Even though oil and natural gas prices are projected to remain significantly higher than coal, their demand is expected to remain relatively the same as it was in 1984. Coal, primarily a utility and large industrial boiler fuel, is not expected to significantly penetrate the light industrial, commercial, residential or transportation sectors now dominated by oil and natural gas.

Coal is demand driven. The capacity exists to increase coal supplies to meet significant increases in demand. To make coal utilization look more attractive, the Department of Energy and the private sector have been conducting research through proof-of-concept on a wide variety of coal technologies aimed at improving the economics of using coal, improving the environmental performance associated with the use of coal and converting coal into forms that could allow it to be used as a lower cost substitute to oil and natural gas.

On December 19, 1985, P.L. 99-190, "An Act Making Appropriations for the Department of the Interior and Related Agencies for the Fiscal Year Ending September 30, 1986, and for Other Purposes," was signed into law. This statute, among other things, provides funds to conduct cost-shared clean coal technology projects for the construction and operation of facilities that would demonstrate the feasibility of future commercial applications of such technology.

P.L. 99-190 makes available a total of $397.6 million for this program, as follows: $99.4 million in FY 1986, $149.1 million in FY 1987, and $149.1 million in FY 1988. Funding is provided from the $397.6 million for contracting, travel, and ancillary costs incurred by the Department of Energy for implementation of the Clean Coal Technology Program. P.L. 99-190 also requires a minimum of 50 per centum cost sharing by the private sector on each project, cost sharing in each phase of each project, constraints on valuation of "in-kind" cost sharing by the private sector, time limitations for issuing the solicitations, proposal preparation and project selection(s), among other things.

The Clean Coal Technology Program is related to, but not directly a continuation of, the effort that was undertaken by DOE pursuant to Section 321 of the "Act Making Continuing Appropriations for Fiscal Year 1985," P.L. 98-473, 98 Stat. 1874. Section 321 directed the Secretary of Energy to solicit from the private sector "statements of interest in, and proposals for projects employing emerging clean coal technologies," analyze the information received, and submit a report to Congress that "assesses the potential usefulness of each emerging clean coal technology... and ...identifies the extent to which federal incentives, including financial assistance, will accelerate the commercial availability of these technologies." In response to the November 27, 1984, Program Announcement, 49 Fed. Reg. 46696, DOE received one hundred and seventy-five submissions with project values totaling over $8 billion. On May 1, 1985, DOE submitted its findings in the "Report to Congress on Emerging Clean Coal Technologies" (DOE/S-0034).

In August 1985, the President signed into law H.R. 2577, "Making Supplemental Appropriations for the Fiscal Year Ending September 30, 1985, and for Other Purposes."

The Conference Report 99-236 accompanying H.R. 2577 advised DOE to immediately begin the preparation of a competitive solicitation for cost-shared clean coal technology projects, to consult with the Environmental Protection Agency (EPA) on technologies traditionally supported by EPA and on environmental regulatory considerations, and provided guidelines for the preparation of the solicitation in addition to those cited earlier in the accompanying Senate Report 99-82.

Program Goals and Objectives

The overall goal of the Clean Coal Technology Program is to conduct cost-shared construction and operation of clean coal technology projects to demonstrate the feasibility of future commercial applications of these technologies. When complete, it is expected that these demonstration projects will provide sufficient technical, economic, environmental, health and safety, and operational information at a large enough scale to enable the private sector to make rational commercialization decisions.

It is the intent of the Department to meet this goal in accord with the following program objectives:

- Issue a competitive solicitation for Federal assistance to the private sector applicable to the broad array of coal-based emerging clean coal technology systems for use in all energy market applications.
- Enter into cost-shared cooperative agreements with the private sector to demonstrate selected systems.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
CLEAN COAL TECHNOLOGY
ENERGY SECURITY RESERVE

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Clean coal technology (FE)					
Cooperative agreements:					
Operating expenses	$ ...	$97,909	$97,909	$147,112	$+49,203
Subtotal	...	97,909	97,909	147,112	+49,203
Program direction:					
Operating expenses	$ ...	1,491	1,491	1,988	+497
Subtotal	...	1,491	1,491	1,988	+497
Total					
Operating expenses	...	99,400	99,400	149,100[1/]	+49,700
Clean coal technology	$ ...	$99,400	$99,400	$149,100	$+49,700

[1/] FY 1987 funding was made available via the FY 1986 Continuing Resolution.

Authorization: P.L. 96-126, P.L. 98-473
P.L. 99-190

Summary of Changes

FY 1986 Appropriation enacted	$ 99,400
Program increases and decreases:	
Coal Coal Technology	
o P.L. 99-190 made available $99.4 million in FY 1986, $149.1 million in FY 1987, and $149.1 million in FY 1988	+49,700
FY 1987 budget request	$149,100

Coal coal technology:

Goals/Objectives:

The principal goal of this program, as stated in P.L. 99-190, is "for the purposes of conducting cost-shared clean coal technology projects for the construction and operation of facilities to demonstrate the feasibility of future commerical operation." It is targeted at the wide variety of emerging clean coal technologies located in the U.S., and using U.S. coals in a wide variety of market applications.

In FY 1986, in response to P.L. 99-190, the Department issued a competitive solicitation requesting proposals for cost-shared clean coal technology demonstration projects and selected projects for cooperative agreement negotiations. In FY 1987, DOE will complete the cooperative agreement negotiations and work called for under the agreements will be initiated.

FY 1986 Accomplishments:

- o Issue a competitive solicitation requesting proposals for clean coal technology demonstration projects.
- o Select projects for cooperative agreement negotiations.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Cooperative agreements	$97,909	$147,112	$+49,203

FY 1987 funding for cooperative agreements would support, on a cost-shared basis with the private sector, demonstration of advanced technologies to gather the data needed for their ultimate commercialization. Successful demonstration and commercial application of clean coal technologies could result in increased coal utilization and make coal a more desirable fuel in markets now dominated by oil and gas.

To accomplish these goals, the Department will issue a competitive solicitation for Federal assistance to the private sector that are applicable to the broad array of coal-based emerging clean coal technology systems for use in all energy market applications. After evaluating all submitted proposals, the Department would then enter into cost-shared cooperative agreements with the private sector to demonstrate the selected systems.

Program direction	$ 1,491	$ 1,988	$ +497

In order to implement and execute the Clean Coal Technology Program, the Department has been given the authority to charge certain costs related to program direction against appropriations for this program. These costs represent primarily travel and contracted technical support related to the pre-award proposal evaluation phase and the post-award monitoring and data base activities.

The FY 1987 funding for program direction will provide for contractual services and in-house support in performing post-award monitoring and technical data base activities. These activities would include attendance at project review meetings and the collection, processing and dissemination of technical data.

In addition, funding is provided to cover travel costs of Energy Technology Centers and Headquarters personnel associated with post-award monitoring activities.

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

VOLUME 6

TABLE OF CONTENTS

Appropriation Language 15

Amounts Available for Obligation 16

Summary of Estimates by Major Category 17

Program Overview 19

COAL:

Control Technology and Coal Preparation 27
Advanced Research and Technology Development 37
Coal Liquefaction 49
Combustion Systems 59
Fuel Cells 67
Heat Engines and Heat Recovery 73
Underground Coal Gasification 79
Magnetohydrodynamics 85
Surface Coal Gasification 89

PETROLEUM:

Advanced Process Technology 101
Enhanced Oil Recovery 107
Oil Shale 115

GAS:

Unconventional Gas Recovery 121

POLICY AND MANAGEMENT 129

COOPERATIVE R&D VENTURE POOLS 137

DEPARTMENT OF ENERGY

Proposed Appropriation Language

Fossil Energy Research and Development

(Including transfer of Funds)

For necessary expenses in carrying out fossil energy research and development activities, under the authority of the Department of Energy Organization Act (Public Law 95-91), including the acquisition of interest, including defeasible and equitable interests in any real property or any facility or for plant or facility acquisition or expansion, [$312,848,000] $82,767,000, to remain available until expended, of which [$535,000] $221,000 is for the functions of the Office of the Federal Inspector for the Alaska Natural Gas Transportation System established pursuant to the authority of Public Law 94-586 (90 Stat. 2908-2909), and [$8,230,000 to be derived by transfer from unobligated balances in the "Fossil energy construction" account, $2,010,000 to be derived by transfer from the account entitled "Alternative fuels production", of which $200,000 is derived from Public Law 98-146 for a wood pellet gasifier facility, and $2,775,000] in addition, $437,000 to be derived by transfer from amounts derived from fees for guarantees of obligations collected pursuant to section 19 of the Federal Nonnuclear Energy Research and Development Act of 1974, as amended (42 U.S.C. 5919), and deposited in the "Energy security reserve" established by Public Law 96-126: Provided, That no part of the sum herein made available shall be used for the field testing of nuclear explosives in the recovery of oil and gas: Provided further, That notwithstanding any other provision of law, funds [appropriated] available under this head in Public Law [97-394 for a Western Hemisphere alternative fuels facility feasibility study, which remain unobligated,] 99-190 for implementation of the June 1984 multiyear, cost-shared magneto-hydrodynamics program shall be available for carrying out any fossil energy research and development activities[: Provided further, That $15,000,000 of the sum provided under this heading shall be available for demonstration of the Kilngas coal gasification process, with the provision that the United States Treasury shall be repaid up to double the total Federal expenditure for such process from proceeds to the participants from the commercial sale, lease, manufacture, or use of such process].

[Of the funds herein provided, $29,000,000 is for implementation of the June, 1984 multiyear, cost-shared magneto-hydrodynamics program targeted on proof-of-concept testing: Provided further, That 10 per centum private sector cash or in-kind contributions shall be required for obligations incurred in fiscal year 1986, 20 per centum private sector cash or in-kind contributions shall be required for obligations in fiscal year 1987, and for each subsequent fiscal year's obligations private sector contributions shall increase by 5 per centum over the life of the proof-of-concept plan: Provided further, That existing facilities, equipment, and supplies, or previously expended research or development funds are not cost-sharing for the purposed of this appropriation, except as amortized, depreciated, or expensed in normal business practice: Provided further, That cost-sharing shall not be required for the costs of constructing or operating government-owned facilities or for the costs of Government organizations, National Laboratories, or universities and such costs shall not be used in calculating the required percentage for private sector contributions: Provided further, That private sector contribution percentages need not be met on each contract but must be met in total for each fiscal year.] (Department of the Interior and Related Agencies Appropriations Act, 1986, as included in Public Law 99-190.)

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
AMOUNTS AVAILABLE FOR OBLIGATION
FOSSIL ENERGY RESEARCH AND DEVELOPMENT
(In thousands of dollars)

	FY 1986	FY 1987
Appropriation:		
Definite	$310,971	$ 82,767
Sequestration of Funds Pursuant to Gramm, Rudman, Hollings Bill	-14,017	...
Permanent Authority	15,000	...
Appropriation Total	$311,954	$ 82,767
Unobligated Balances:		
Start of year unobligated balances	$ 56,904	$ 67,948
Unobligated balances transferred to other appropriations	...	...
Unobligated balances transferred from other appropriations	4,785	437
End of year unobligated balances	-67,948	-1,062
Recovery of prior year obligations	6,000	...
Total Obligations	$311,695	$150,090

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Budget Authority in Thousands of Dollars)

	FY 1985 Actual	FY 1986 Estimate	FY 1987 Request
COAL:			
Control Technology and Coal Preparation	$ 34,791	$ 31,950	$ 18,147
Advanced Research and Technology Development	30,804	33,849	27,224
Coal Liquefaction	31,110	31,620	9,147
Combustion Systems	30,092	29,113	9,169
Fuel Cells	40,472	34,057	5,000
Heat Engines and Heat Recovery	11,850	12,314	7,942
Underground Coal Gasification	5,705	4,072	---
Magnetohydrodynamics	30,721	27,717	---
Surface Coal Gasification	35,134	41,323	5,598
Subtotal, Coal	250,679	246,015	82,227
PETROLEUM:			
Advanced Process Technology	5,364	5,523	1,811
Enhanced Oil Recovery	11,702	11,454	4,484
Oil Shale	14,628	12,136	3,595
Subtotal, Petroleum	31,694	29,113	9,890
GAS:			
Unconventional Gas Recovery	10,142	8,503	5,252
Subtotal, Gas	10,142	8,503	5,252
POLICY AND MANAGEMENT:			
Headquarters Program Direction	8,273	13,380	11,260
ETC Program Direction	37,907	39,265	28,740
Federal Inspector for the Alaska Gas Pipeline	1,401	511	221
Capital Equipment	4,425	2,865	---
Construction	4,916	3,332	---
Subtotal, Policy and Management	56,922	59,353	40,221
COOPERATIVE VENTURE R&D POOLS	---	---	12,500
Subtotal, Fossil Energy	349,437	342,984	150,090
Use of Prior Year Balances and Other Adjustments	-60,389	-31,030	-67,323
Total, Fossil Energy R&D	$289,048	$311,954	$ 82,767

Department of Energy
FY 1987 CONGRESSIONAL BUDGET
MAJOR ACTIVITY OVERVIEW

Fossil Energy

PRINCIPAL ISSUES IN FOSSIL ENERGY BETWEEN NOW AND 2000

Fossil fuels -- oil, natural gas and coal -- accounted for 90 percent of the energy consumed in the United States during 1984, and will supply the majority of the Nation's energy needs well into the next century. Availability of these fuels is thus a major component of the national energy policy.

The resources to supply various fossil fuels domestically have shifted significantly during this century, and will continue to change in the future. At first, wood and then coal were the dominant fuels used during the early phases in the development of modern industrialized societies. The major growth in energy demand has occurred during a period of relatively plentiful and inexpensive supplies of oil and natural gas -- a trend which began in the mid-1920's. As a result, both the economies of the developed countries and the economic aspirations of many lesser developed countries are based upon energy production and utilization technologies (and their associated highly sophisticated, manufacturing and distribution infrastructures) to which these premium[1] fossil fuels are essential. Currently, oil and gas account for approximately 65 percent of both free world and U.S. energy consumption. From the perspective of relative resource abundance, this fuel-use pattern is imbalanced. Coal, accounting for over 80 percent of the estimated U.S. recoverable fossil reserves, contributes only some 23 percent of the energy consumption. Oil, the least abundant (and most critical) resource, constituting about 3 percent of U.S. estimated recoverable fossil fuel reserves, accounts for over 42 percent of consumption. If the vast U.S. oil shale and peat resources are included, the imbalance becomes even more pronounced.

The imbalance between the consumption/resource ratio for conventionally produced gas and particularly oil versus that for other far more abundant domestic fuels could have potentially adverse future implications for U.S. energy stability and security. This is reflected in projections done for the U.S. Energy Information Administration's Annual Energy Outlook (published January 1985), which show gross oil imports exceeding 50 percent of domestic liquid needs by 1995 due to the projected availability of moderately priced imports. In spite of this, there are a number of sound business/economic reasons why industry is unlikely to make a rapid transition in fuel-use patterns.

- There are major fuel-consuming sectors (e.g., transportation, industrial process heat applications and small industrial and commercial boilers), where practical technologies for the direct utilization of coal, electricity or renewables have not yet evolved.

- The capital investment currently in place for fuel-specific energy production and utilization equipment is large. The payback period to recover the investment in new capacity is long compared to the frequency of unanticipated (and historically realized) and significant changes in oil prices, market conditions, and environmental concerns. Thus, even if conditions look favorable at a particular point in time for investing in new capacity, there is uncertainty as to whether such conditions will continue to persist.

1/ "Premium" refers to gaseous and liquid fuels, particularly liquids, that command a relatively higher price because of their convenience of use.

- o The front-end capital components of energy costs associated with coal, oil shale, tar sands and other unconventional fossil energy resources are significantly higher than those associated with the intensively utilized conventional liquid and gas resources, and the lead times required for system planning and construction are longer, thus increasing overall risks related to future uncertainties.

- o The inherent potential for unacceptable environmental impacts (and attendant costs) associated with certain abundant fossil resources, such as coal and oil shale, is relatively high.

The potentially slow pace of the shift away from heavy reliance on conventional sources of premium fuels is reflected in projections made for the National Energy Policy Plan (NEPP), which for the year 2010 indicate oil and gas will supply between 44 and 49 percent of total U.S. primary energy consumption (all fuels), with imports representing from 39 to 41 percent of oil and gas consumption. A number of uncertainties exist, however, that make it difficult to estimate the pace of this shift, including: future price and availability of oil and gas from conventional resources (as illustrated by current reversal in world oil price trends); environmental performance requirements; technical, economic and environmental performance of new fossil and other competing technologies; future demand for different fuels; and other market parameters which may change significantly during the life of an investment.

Electricity is an important intermediate activity on the spectrum between energy producer and energy consumer. Electric power generation consumes about 35 percent of the primary energy used in the United States. About 28 percent of the fossil energy used and 82 percent of the coal used is for electricity generation. Current DOE estimates indicate that electricity demand growth is likely to increase at an annual rate of 2.5 percent over the period 1984-2000. Since other end-use fuel demand is projected to increase at a much slower rate than electricity growth, the electricity share of final energy consumption is projected to increase during the remainder of this century.

Availability of an adequate supply of electricity at reasonable costs to meet current and future needs has come to be viewed as a "right" by many consumers. Although sufficient electricity supplies should be available throughout the 1980's, the long-term outlook for continued availability of reliable supplies at reasonable costs is not certain.

NEPP projects that significant additional generating capacity will be required to meet future demands, to replace obsolete facilities, to displace high cost fuels (oil and natural gas) and to provide for effective reserve margins. Based upon NEPP projections, coal use for electricity generation by the year 2000 could amount to 23 percent of total primary energy use. That would account for 84 percent of total coal used domestically. All of this is projected to occur at the same time that environmental questions about coal mining and use continue to be of serious public concern. In terms of tonnages, consumption of coal to generate electricity is expected to grow from the present 664 million tons annually to some 1,059 million tons in the year 2000 - a 60 percent increase in 16 years. If coal is going to attain projected use levels for generating electricity, it is essential that improved technologies be developed to allow the use of coal in both new and existing power plants in an economically competitive and environmentally acceptable manner.

ROLE OF DOE'S FOSSIL ENERGY PROGRAMS

While the Nation is fortunate to have abundant fossil energy resources, diverse and extensive advances are needed in the scientific and engineering knowledge base in order to achieve an effective utilization balance in the long term. Systematic technical advances must occur in all stages of the research, development, and commercialization cycle. To a large extent, this cycle can be described in terms of the path taken by technology development and the stages through which new technologies pass until they reach the market as competitive energy investment options. Stated simply, the technology development path consists of five stages. Basic research seeks to develop fundamental scientific knowledge, including a fundamental understanding of the physical and chemical properties of unconventional fuel sources or energy systems, leading to the definition of new energy R&D concepts. Applied research includes activities to resolve broad engineering and physical science problems in specific fossil technologies and related areas. However, practical utility may not be proven at this stage. Proof-of-concept is where enough has been learned to resolve specific problems to determine the technical and environmental feasibility of the integrated process. Data are generated to evaluate critical scale-up parameters, characterize sub-systems, processes, and products, and to permit preliminary economic projections to be made. Process development is directed at increasingly larger scale engineering design, construction and operation of energy systems with the objective of reducing technical risks and improving the process operability, reliability, economics, and environmental impact. Commercialization consists of a wide variety of efforts to eliminate technical, economic and institutional barriers required for acceptance of a new energy technology into the marketplace.

The latter stages of this cycle are the most costly but the risks are also the most defined and predictable. This is where private sector responsibilities take over to move advanced technologies into commercial reality. The earlier stages (i.e., basic research through proof-of-concept), feed this research and development (R&D) investment pipeline with the results of long-term, high-risk, and potentially high- payoff research. While R&D in these earlier stages may have a very high benefit/cost ratio from the public perspective, private sector investment may be restricted because payoffs are frequently difficult to predict, highly risky or would require an exceptionally long time to be recognized, or cannot be captured by individual firms.

Thus, there are reasons why it may be desirable for the government to undertake certain energy activities including energy conservation programs and, to encourage development of abundant and presently uneconomical or technically difficult domestic resources so that these resources will be more attractive to the marketplace. This includes providing federal funding assistance for early stages of the R&D cycle for the development of new technologies; for R&D to remove environmental uncertainties, and to make resources under federal control available at a fair price; and other actions that do not introduce inefficiencies through inappropriate intervention in the marketplace.

Fossil Energy Strategic Objectives

As discussed in the NEPP, the Administration's goal in energy policy continues to be that Americans should have an adequate supply of energy, maintained at a reasonable cost. This goal presupposes three broad conceptual objectives: energy stability, energy security and energy strength.

Energy stability means a situation in which problems of energy availability and price no longer destablize the U.S. economy and our way of life. Energy security means that adequate supplies of energy are physically available to U.S. consumers from both domestic and foreign souces, and that we are less vulnerable to disruptions in energy supply and better prepared to handle them if they should occur. Energy security leads to energy strength, whereby it is possible to effectively exploit the vast energy resource base of the United States. New supply and utilization technology can contribute to all of these objectives, particularly energy strength.

Implicit in achieving the national goal and objectives described above are the following strategies:

- Minimize federal control and involvement in energy markets while maintaining public health and safety and environmental quality.

- Promote a balanced and diversified energy resource system.

In addition to NEPP, Administration policy and guidance, DOE mission statements, Congressional guidance and analyses of fossil fuel supply and utilization trends and issues provide the framework within which the Office of Fossil Energy R&D program has been developed. Included in this framework are the strategic objectives which follow, and, in effect, provide an indication of how FE programs are addressing the issues outlined earlier.

Recognizing the need to effect an orderly transition to greater utilization of the most abundant domestic fossil fuel resources, two complementary overall strategic objectives have been established for FE:

1. Increase the contribution of coal by improvements in environmental, technical, and economic performance and increase the number of areas of application and flexibility of use of coal-based systems.
2. Increase the effective resource base for premium gas and liquid fuels through enhanced resource recovery and/or production of liquid and gaseous fuel analogs from coal, shale, and tar sands.

The FE program pursues these strategic objectives through activities which identify research opportunities and conduct research (and transfer the results of such research to the user community) in the extraction, processing, and utilization of domestic fossil fuel resources which are not being pursued by the private sector because of high-risk/long-term characteristics. This research should offer substantial potential improvements in terms of enhanced liquid and gaseous fuel supply or reduced demand and/or improved efficiency, economics, or environmental protection. FE plans, coordinates, and carries out research to the extent necessary to establish proof-of-concept and to provide the essential information for the private sector to make process development and commercial plant deployment decisions.

Crosscutting R&D Objectives

There are two strategic objectives that cut across all of the fossil fuel R&D programs. One is that process/technology research will be coupled with the appropriate associated environmental research to economically manage environmental impacts of processing and using fossil fuels. This includes work needed to establish data bases that help mitigate problems rather than merely expand the range of questions and concerns. Energy and environmental objectives may appear to conflict more frequently than converge, but they are not mutually exclusive. The question is not one of "either/or," rather, it is a matter of determining how to achieve a proper balance between technology issues (such as resource recovery, process efficiency, etc.) and environmental intrusions. The objective of this research is to characterize potential impacts and the performance of new and developmental systems in controlling these impacts so that more efficient solutions to environmental concerns are available on a schedule consistent with the development of advanced technology.

The second objective is that all process/technology research will be coupled to advanced research activities needed to improve the understanding of fundamental scientific and engineering mechanisms. Such understanding is critical to effectively assessing the ways fossil resources can be utilized, and provides the basis for new ideas to lead to future ~~major~~ innovations in fossil fuel technologies. These activities are directed toward the advancement of those scientific and technical disciplines that underlie the development of all Fossil Energy technologies. They include fundamental research on physical, chemical and thermodynamic characteristics of fossil fuels and their derivatives, fluid phenomena, solids transport, multiphase flow, combustion, materials, instrumentation and analytical techniques, environmental sciences, geosciences, innovative concepts, coordination of international activities in Fossil Energy, and sponsoring long-term scientific coal research at universities.

Program Objectives

There are a number of program objectives listed below that apply to the research and development in Fossil Energy.

Coal:

- Foster development of economic methods for modifying the overall physical characteristics of coal (reduce ash and sulfur, but do not change state) to permit the resultant cleaned/modified coal to be used dry or as a slurry to permit utilization in a number of combustion systems.
- Identify and foster development of new processes and/or equipment that are capable of using coal directly or as modified fuel forms in such a way as to increase the efficiency in the use of the fuel, extend its applicability and/or allow for its substitution for oil or gas.
- Foster development of lower cost more environmentally-acceptable technologies for the generation of electricity from coal which can increase the flexibility of the utility industry to meet capacity expansion and replacement needs.
- Identify and foster development of new, useful and environmentally acceptable approaches for managing coal cleaning waste, ash, and other waste product disposal.
- Foster development of improved and more economic and environmentally acceptable technologies to allow coal to be converted (including both above ground and underground processes) into a gaseous fuel or synthesis gas suitable for the requirements of new as well as existing end uses.
- Foster development of economically attractive and environmentally acceptable technologies to allow coal to be converted (including both direct and indirect liquefaction) to a complete range of petroleum substitutes that can be used for transportation, industrial, utility, and chemical applications.
- Identify and foster development of new fuel forms that can be produced from coal (other than those cited above) as an energy source in existing or new energy conversion systems.

Oil:

- Foster development of economically attractive and environmentally acceptable technologies for (1) enhanced light oil recovery, (2) in situ thermal recovery of heavy oil and tar sand bitumen, and (3) conversion of oil shale, all of which can add to the supplies of oil from conventional sources.

Gas:

- Foster development of unconventional and novel natural gas resources which can add to the supplies of natural gas from conventional sources.

While these objectives provide the framework for most FE R&D activities, it should be noted that there are other activities that are performed within the context of the national energy goal and strategies. These activities, which reside in FE because of its management and technical experience/expertise include: general policy and strategic studies related to fossil energy; studies and analysis on fossil fuel transportation issues and certain energy supply aspects of leasing; management of the Liquefied Gaseous Fuels Spill Test Facility program to address safety issues associated with large spills; and support to federal agencies on fossil energy related matters.

Program Guidelines

In addition to the above program objectives, there are a number of guidelines and criteria that are observed in the planning and execution of FE programs. Two of the most prominent include private sector participation and international cooperation. Regarding the former, private sector input is solicited during the program planning process through a variety of mechanisms, including advisory groups, workshops and peer reviews. In the program execution phase, substantial emphasis is placed on cost-sharing to facilitate the transfer of technology to the private sector and to reduce federal expenditures. Inherent in this approach is an attempt to attract research performers that have a long-term institutional commitment to an area of research and to the ultimate application of the research results. In general, industry will be more willing to invest its money in potential high payoff R&D as risks and uncertainties are reduced, and thus cost-sharing frequently becomes more attractive as R&D approaches the proof-of-concept stage.

One of the primary goals of all the applied research areas in FE is to effectively transfer technology from Federal and university laboratories to private industry. The earlier industry is involved, and the more directly that the research agenda is guided by the companies' own economic self-interest, the more effective the transfer is likely to be. In FY 1987, Fossil Energy will "pilot-test" a special case of this cost-sharing approach known as cooperative ventures. The approach will be to solicit proposals from the private sector in a broad area of applied research, where two or more firms would propose to form a "pre-competitive" cooperative venture with DOE. It is DOE's intent to impose minimal constraints on potential proposals and to select on the basis of technical and financial merit among all proposals regardless of the specific areas proposed for further R&D. Resultant royalties or other profits would be shared proportionately by the participants. To the extent that industry is willing to enter into such ventures, benefits could result such as better leveraging of scarce Federal funds and aiding technology transfer by increasing the number of private sector participants.

Many of the same factors that make participation with the U.S. private sector desirable have motivated FE to seek international cooperative efforts. There is additional interest in that the U.S. Government is actively seeking to facilitate the long-term reduction of U.S. and international dependence on oil by supporting research that could lead to the development and substitution of other energy forms. The overriding concern is that any cooperative efforts must support FE program objectives.

FOSSIL ENERGY PROGRAM BUDGET

The levels of federal support in the budget for the various Fossil Energy technologies are believed to be appropriate given the need to progressively reduce Federal budget deficits, and when compared to the needs and to the levels of federal funding both for other energy related technologies and for other governmental activities.

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

COAL

VOLUME 6

TABLES OF CONTENTS

Control Technology and Coal Preparation 27

Advanced Research and Technology Development 37

Coal Liquefaction 49

Combustion Systems 59

Fuel Cells 67

Heat Engines 73

Underground Coal Gasification 79

Magnetohydrodynamics 85

Surface Coal Gasification 89

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
COAL
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1/] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Control technology and coal preparation (FE)					
Coal preparation:					
Operating expenses	$10,965	$12,716	$12,716	$ 6,443	$ -6,273
Subtotal	10,965	12,716	12,716	6,443	-6,273
Flue gas cleanup:					
Operating expenses	14,511	10,952	10,952	7,541	-3,411
Subtotal	14,511	10,952	10,952	7,541	-3,411
Gas stream cleanup:					
Operating expenses	7,348	7,105	7,105	3,839	-3,266
Subtotal	7,348	7,105	7,105	3,839	-3,266
Waste management:					
Operating expenses	1,967	1,177	1,177	324	-853
Subtotal	1,967	1,177	1,177	324	-853
Total					
Operating expenses	34,791	31,950	31,950	18,147	-13,803
Control technology and coal preparation	$34,791	$31,950	$31,950	$18,147	$-13,803
Staffing Total FTE's: Direct ...	54	55	55	45	-10
Indirect .	30	28	28	22	-6

1/ Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer.	General Reduction	Gramm-Rudman-Hollings	Total
Control Technology and Coal Preparation (FE)				
Coal Preparation				
Operating Expenses	$13,305	$-69	$-520	$12,716
Flue Gas Cleanup				
Operating Expenses	11,460	-60	-448	10,952
Gas Stream Cleanup				
Operating Expenses	7,433	-38	-290	7,105
Waste Management				
Operating Expenses	1,232	-7	-48	1,177
Subtotal, Control Technology and Coal Preparation	$33,430	$-174	$-1,306	$31,950
General Reduction:				
Operating Expenses	-174	174	-	-
Total, Control Technology and Coal Preparation	$33,256	-	$-1,306	$31,950
Operating Expenses	33,256	-	-1,306	31,950

Summary of Changes

FY 1986 Appropriation enacted	$31,950
Program increases and decreases:	
Coal Preparation	
o Research efforts will be completed and not continued into FY 1987 in the areas of low rank coal hot water drying, ultrasonic comminution, fine coal dewatering, and contracted efforts in the development of advanced physical coal cleaning concepts. Technology base activities will be continued in the areas of Gravimelt development, chemically modified coals, microbial desulfurization, joint DOE/EPRI development and test, ultrafine coal characterization, and in-house research on chemical coal cleaning, physical coal cleaning and organic sulfur chemistry	-6,273
Flue Gas Cleanup	
o Complete activities on electron beam processess, pressure hydrated lime furnace sorbent injection, fine particulate control and dry scrubber SO_x/NO_x process	-3,411
Gas Stream Cleanup	
o Complete subpilot testing of PFBC particulate removal devices and zinc ferrite sorbent testing at subpilot scale; terminate tests of second generation PFBC particulate removal devices; continue contaminant control base activities	-3,266
Waste Management	
o Complete several ongoing Waste Management activities and continue technology base activities which include sampling and characterization of organic and inorganic species in solid wastes produced by emerging technologies, and energy recovery from coal preparation wastes	-853
FY 1987 budget request	$18,147

Control technology and coal preparation:

Goals/Objectives:

Economic and social barriers to a rapid, widespread replacement of oil by coal derive mainly from quality differences. The inert matter in even our best coals imposes cost penalties in transportation and utilization. Additional costs are incurred in burning most U.S. coals because of the considerable sulfur or nature of the mineral constituents or trace elements they contain. This added cost burden results from specific requirements for environmental management, waste disposal, combustor design modifications, and ancillary equipment capacity. In summary, the ultimate cost of electricity, process heat, or shaft horsepower is strongly dependent on technologies dealing with coal quality, environmental emissions, and waste disposal. In-depth research for interdependent technologies of coal beneficiation, gas cleaning, and waste disposal is essential to critical economic and engineering analyses of site-specific coal utilization requirements. This, in turn, is necessary to achieve the highest degree of cost effectiveness in the expanded utilization of U.S. coals. The goals of the Control Technology and Coal Preparation activity are to identify and develop a range of advanced engineering approaches capable of:

- Upgrading the quality of U.S. coals to quality levels that will allow coal-based fuels to penetrate those markets now being supplied by liquid fuels in an economically sound and environmentally acceptable manner.
- Improving the ability to remove flue gas pollutants for compliance with emission standards.

- Developing a capability to reduce the emissions of suspected acid rain precursors from existing, uncontrolled coal-fired boilers that is significantly lower in cost than commercially available methods.
- Removing undesirable substances produced during gasification and/or combustion from process streams, thus protecting utilization equipment such as turbines and fuel cells.
- Providing waste disposal technologies that will permit compliance with environmental pollution regulations without excessive costs.

The functional organization of this activity forms four logical subactivities: (1) Coal preparation; (2) Flue gas cleanup; (3) Gas stream cleanup; and (4) Waste management.

Coal preparation is directed toward the development of advanced coal cleaning technologies that will reduce the ash and sulfur content of U.S. coals so that the product can be formulated into a high quality fuel that could replace oil and/or gas and reduce environmental emissions of suspected acid rain precursors from coal-fired power plants in both new and retrofit applications. Flue gas cleanup addresses the removal of pollution causing contaminants from the stack gases of conventional combustion units to meet environmental standards. Efforts will be focused on fundamental research for processes for the combined removal of NO_x, SO_x, and particulates, both for utility and industrial applications. Gas stream cleanup includes the technology for removal of contaminants from gasifier and combustor process streams prior to utilization in advanced power conversion cycles such as gas turbines and fuel cells. Both hardware and environmental protection are key concerns. Waste management focuses primarily on waste sampling and characterization from coal preparation wastes.

FY 1986 Accomplishments:

Major accomplishments expected in FY 1986 include:

Coal Preparation
- Completed development of low-rank coal hot-water drying process and investigation of low-rank fine coal cleaning.
- Completed testing of Gravimelt and microwave chemical coal cleaning reactors at 20 lb/hr scale.
- Issued PRDA to identify and investigate advanced concepts for chemically modified coals.
- Continued development of advanced physical coal cleaning processes including joint DOE/EPRI test at EPRI Coal Cleaning Test Facility.
- Continued research on microbial removal of organic sulfur from coal.
- Completed coal preparation research activities at Southern Illinois University.
- Completed research on coal characterization, chemical cleaning, physical cleaning and ancillary operations at Ames National Laboratory.
- Completed research on microbubble flotation technology advanced concepts.
- Completed efforts on ultrasonic comminution and fine coal dewatering.
- Continued research on the chemical and physical characterization of ultra-fine coal.
- Continued research on the beneficiation of chemically modified coals and advanced concepts for chemical coal cleaning.
- Continued research on advanced physical coal cleaning concepts such as selective agglomeration, ultrafine coal flotation, electrostatically enhanced magnetic separation and true heavy liquid cycloning.

Flue Gas Cleanup
- Completed bench scale evaluation of electron beam charging and acoustic agglomeration techniques for fine particulate control.
- Continued proof-of-concept test and evaluation of candidate acid rain control technology processes.
- Completed sorbent development for boiler injection applications for SO_2 control.
- Completed proof-of-concept test and evaluation of the electron beam/ammonia simultaneous NO_x/SO_x cleanup process.

- o Continued proof-of-concept test and evaluation of the fluidized bed copper oxide simultaneous NO_x/SO_x cleanup process.
- o Continued research on advanced NO_x/SO_x chemistry and thermodynamics, and bench scale development of advanced NO_x/SO_x cleanup processes.
- o Completed research on potential process modifications for achieving combined NO_x/SO_x control (dry scrubber process).
- o Completed evaluation of Glo-Klen catalyst.

Gas Stream Cleanup

- o Terminated program definition phase for selecting cleanup devices for PFBC system integration proof-of-concept testing.
- o Continued economic/systems analysis for PFBC alkali metals and particulate removal devices and desulfurization processes to determine their future potential.
- o Completed the testing of the zinc ferrite desulfurization process on a fluidized bed gasifier.
- o Continued investigations into process modification control methods for ammonia, aromatic hydrocarbons, and tar cracking.
- o Continued on-line coal gasification tests for selected high temperature, high pressure sulfur removal processes for gasifier/turbine combined cycle application.
- o Conducted bench scale testing of novel high temperature and pressure desulfurization processes using gasification produced fuel gas.
- o Completed research on control and removal of trace contaminants of arsine, aromatic hydrocarbons, and hydrogen chloride to molten carbonate fuel cells.
- o Initiated preliminary experimental research of novel processes to treat regeneration tail gases from high temperature desulfurization of coal gases.
- o Continued test and evaluation of soot and particulate control in coal fuel gas to molten carbonate fuel cells.
- o Completed PFBC subpilot testing of ceramic cross flow filter and screenless granular bed filter.
- o Completed coal gasification bench scale testing of ceramic bag filter and electrostatic precipitator.
- o Completed laboratory investigation of acoustic agglomeration, a second generation particle control concept.
- o Completed investigation of boundary layer turbulence in cyclone separators to establish its form, impact on particle collection and possible methods of suppression.
- o Initiated direct coal fired turbine studies PRDA.
- o Continued research on specific instrumentation problems; investigation of chemical and physical properties of contaminants.
- o Determined concept feasibility of SO_2 removal with selected sorbents.

Waste Management

- o Continued sampling and characterization of organic and inorganic species in solid wastes produced by emerging coal use technologies.
- o Completed initial phase of waste management laboratory analyses of coal wastes.
- o Continued adsorption and degradation studies of polyaromatic hydrocarbons (PAH's) compounds in soil.
- o Continued field study initiated during last quarter of FY 1985 with identification and establishment of multi-sites for monitoring leachate and behavior of solid wastes under actual field conditions.
- o Continued R&D for extracting energy from coal preparation wastes.
- o Continued MIS data base activity.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Coal preparation	$12,716	$ 6,443	$ -6,273

The goal of the coal preparation program is to develop coal cleaning technology to reduce the ash and sulfur content of U.S. coals so that the product can be formulated into a high quality fuel that could replace oil and/or natural gas and reduce environmental emissions in both new and retrofit applications in utility boilers, industrial boilers and process heaters, residential/commercial boilers and furnaces, and heat engines such as gas turbines and diesel engines.

Research efforts will be completed and not continued into FY 1987 in the areas of low rank coal hot water drying, ultrasonic comminution, fine coal dewatering, and contracted efforts in the development of advanced physical coal cleaning concepts.

Most coals resist cleaning by conventional practices either because the ash and sulfur constituents are too finely dispersed in the coal structure or because the organic sulfur content, which does not respond to physical cleaning, is too high. The principal thrust of the coal preparation program is thus directed toward:

o New and advanced cost-effective technologies to clean and condition finely comminuted (ground) coal as necessary to liberate finely dispersed pyritic sulfur and ash particles.
o Advanced experimental methods to extract organic sulfur from coal.

The program encompasses laboratory research efforts focused on the removal of finely dispersed mineral matter impurities, pyritic sulfur, and organic sulfur from all coals. The program includes research on physical and chemical beneficiation techniques and supporting research such as micro-characterization. In the physical cleaning area, selective coalescence, froth flotation, and specific gravity techniques which have demonstrated the ability to remove 90 percent of the pyritic sulfur from selected coals, are being developed. Instrumentation methods such as scanning electron microscopy, image analysis, etc., are being utilized for characterizing the finely ground raw coal and cleaned products in order to develop the basic data needed in the development of the various cleaning technologies.

The cleaned coal products developed under this subactivity will become feedstock for activities in Combustion Systems and Heat Engines aimed at the conversion of existing utility and industrial units from oil or gas to coal; new units fired either conventionally or by coal slurries; direct firing of coal in power conversion equipment (e.g., gas turbines and diesels); export steam coal; and for utilization in existing coal-fired boilers as a cost-effective means of reducing emissions of suspected acid rain precursors. New equipment designs and/or conversion of existing units to coal or coal-based slurries, initiated in the late 1980's, will clearly benefit from the availability of the engineering data developed in this program.

The following major accomplishments are anticipated for FY 1987:

o Continue work on the characterization of ultrafine coal to determine the beneficiation potentials of alternative advanced physical fine coal cleaning technologies.
o Continue in-house research on the beneficiation of chemically modified coals, advanced concepts for chemical coal cleaning, and in-house studies of fundamental organic sulfur chemistry.
o Continue research on advanced physical coal cleaning concepts such as: selective agglomeration, ultra-fine coal flotation, electrostatically enhanced magnetic separation and true heavy liquid cycloning.
o Complete design of Gravimelt continuous operation chemical coal cleaning system.
o Continue joint DOE/EPRI project to develop and test advanced physical coal cleaning concepts.
o Continue research to develop techniques for microbial removal of organic sulfur from coal.
o Continue investigation of advanced concepts identified in FY 1986 for chemically modified coals.

	FY 1986 Approp.	FY 1987 Request	Net Change
Flue gas cleanup	$10,952	$ 7,541	$ -3,411

This program focuses on the development of technology for cost-effective, and environmentally superior processes that remove pollutants from coal combustion gas streams in both utility and industrial boilers. Its intent is to help assure that existing and projected utilization of the nation's most abundant energy resource, coal, can continue without adverse environmental effects.

The FY 1987 program reflects completion in FY 1986 of research and development activities in a number of technology areas including electron beam based processes, pressure hydrated line furnace sorbent injection, fine particulate control technology, and the dry scrubber SO_x/NO_x control process.

The primary pollutants of concern as regulated and identified in the New Source Performance Standards (NSPS), consist of sulfur oxides (SO_x), nitrogen oxides (NO_x), and particulates. SO_x are formed in the combustion process as the result of the oxidation of sulfides contained in the mineral portion of the coal as well as the oxidation of organically bound sulfur. Most of the sulfur is oxidized to sulfur dioxide (SO_2) with a small percentage oxidized to sulfur trioxide (SO_3). Nitric oxide (NO) is formed during the combustion process from the reaction of molecular nitrogen and oxygen in the combustion air (thermal NO) and from the oxidation of nitrogen compounds in the coal (fuel bound NO). While essentially 100 percent of the nitrogen oxide consists of NO, it is reported as NO_x because the EPA standard was written as the nitrogen dioxide (NO_2) equivalent of all nitrogen oxides. Particulates result from the ash content of the coal.

Existing flue gas desulfurization technology is capable of meeting sulfur removal requirements but is very costly and in many cases merely converts an air pollution problem to a solid waste disposal problem in the form of difficult-to-handle sludges, the disposition of which measurably adds to overall environmental control costs. Combustion modification can control NO_x emissions to existing standards. If these standards were to be tightened, however, an additional process would have to be added. Based on available technology, this process would most likely involve a gaseous phase NO destruction technique by reaction with ammonia in the presence of a catalyst. The addition of a process of this type for NO control would measurably contribute to the cost and complexity of the overall environmental control system. Therefore, the primary emphasis of the flue gas cleanup program has been placed on approaches to attain these high levels of SO_2 and NO control in a more cost effective manner, namely through the development of processes with the potential to remove both pollutants simultaneously in a one process step. In order to avoid the problems and costs associated with the handling and disposal of scrubber sludges, primary consideration will be given to those processes that generate relatively benign or possibly useable or marketable waste products.

In addition to the technology being developed for application to new construction under existing stringent requirements, there is a need for the development of low cost, retrofittable technology for the control of acid rain precursor emissions from existing plants. Total replacement of existing plants, with new plants meeting NSPS, is not expected until at least the year 2020. Currently available options for SO_2 control consist primarily of conventional physical coal cleaning, fuel switching, and wet and dry scrubbing. Each has associated advantages and disadvantages. Conventional coal cleaning is already in fairly wide practice where it is presently economical to do so. Capability, to significantly reduce the sulfur content of coals by conventional coal preparation, however, is limited since only some of the inorganic sulfur contained in the mineral portion of the coal can be removed. Switching to low sulfur coals is likely to severely impact the high sulfur coal industry, increase fuel costs due to greater demand as well as higher transportation costs, and cause plant derating unless substantial plant modifications are undertaken to accommodate the different properties characteristic of low sulfur coal. Wet and dry scrubbers are effective (in excess of 90 percent SO_2 control), but are relatively expensive to purchase and operate. Reliability and availability have been problem areas as well as waste handling and disposal. Therefore, development of a low cost technology of relatively modest performance that is capable of being retrofitted to existing boilers would greatly enhance the capability for attaining SO_2 reductions.

The need for and justification of a Federal role in this area is clear cut. System requirements are essentially set by Government regulations. Because of the lung lead-time between the initiation of research and the eventual commercialization of technology, the private sector is for the most part unwilling to pursue this type of work on their own since changing regulations can render their developments obsolete and their expenditures fruitless.

Anticipated FY 1987 accomplishments include:

- o Complete proof-of-concept test and evaluation of the low temperature dry hydrate and dolomite lime slurry induct injection acid rain control technology processes.
- o Continue research in advanced NO_x/SO_x chemistry and laboratory/bench scale development of advanced NO_x/SO_x cleanup processes.
- o Continue proof-of-concept test and evaluation of the fluidized bed copper oxide simultaneous NOx/SOx cleanup process.

	FY 1986 Approp.	FY 1987 Request	Net Change
Gas stream cleanup	$ 7,105	$ 3,839	$ -3,266

The FY 1987 program reflects completion in FY 1986 of a number of research and development activities including subpilot testing of PFBC particulate removal devices, alkali control devices and zinc ferrite sorbent testing.

The primary objective of this program is to develop the required technology base in gas stream cleanup for applications in post combustion/utilization devices used as advanced power conversion systems including both molten carbonate fuel cells and turbines. Turbine cleanup concerns removal of contaminants from gasification fuel gases, pressurized fluidized bed combustors and direct coal-fired combustor gas streams. The high temperature, high pressure contaminant removal control technologies have direct application to fossil fuel conversion processes including oil shale mist particulate separation and methanation shift conversion (catalyst protection from poisoning, etc.). The gas streams range up to 2400°F in temperature and 500 psi in pressure and contain contaminants that, if not removed, will cause failure of the conversion cycle equipment, as well as prevent meeting the environmental emissions standards. Cleanup at an elevated temperature offers advantages of increased cycle thermal efficiency and reduced capital cost for downstream power conversion applications. Capital cost reductions are attributable to the elimination of the need for process equipment to quench and reheat the gas stream and to treat the contaminated waste water from the quenching process. Contaminants of concern are dependent upon the specific application. Energy conversion systems will have to meet NSPS requirements in terms of NO_x, SO_x and particulate emissions. Emphasis in combustion gas cleanup has been on the control of alkalies and particulates found in pressurized fluidized bed combustor (PFBC) gas streams powering gas turbine combined cycles. The PFBC has demonstrated the capability to meet NSPS with respect to NO_x and SO_x emissions. The turbines, however, are subject to corrosion, erosion, and deposition. Corrosion in PFB turbines is primarily caused by the presence of alkali surface compounds in the liquid state. Erosion results from the impact of high velocity particulate material. Deposition is caused by a buildup of fine particles on the turbine surfaces. Since the PFB gas turbine operates on sensible heat from the gas stream, it is essential that cleanup processes be accomplished at or near bed temperature. At present, there are no commercially available processes for alkali vapor removal. The gasifier can be used as an energy source for either a gasifier/gas turbine combined cycle or a fuel cell. In addition to the alkalies and particulates previously mentioned, the gasifier gas turbine system must control NO_x precursors such as ammonia as well as sulfur compounds. For fuel cell applications the control of suflur is especially critical since tolerance to sulfur compounds is on the order of 0.1 to 1.0 parts per million to minimize sulfide formation at the nickel anode. The fuel cell also requires stringent control of other contaminants in the fuel gas stream such as chlorides and particulates.

Anticipated FY 1987 accomplishments include:

- Continue process modification control methods for ammonia.
- Continue fundamental R&D of particulate control and SO_2 control concepts for direct fired coal-fueled turbines.
- Complete particulate control tests for gasification.
- Continue instrument development (alkali and particulate - real time) to insure control of cleanup systems.
- Conduct fundamental R&D of the mechanisms of contaminant formation, interaction and removal in gas stream cleanup technology.
- Continue contaminant tests for molten carbonate fuel cells (MCFC).

	FY 1986 Approp.	FY 1987 Request	Net Change
Waste management	$ 1,177	$ 324	$ -853

The goal of the waste management program is to promote the development of waste management technologies that will permit existing and advanced fossil fuel utilization processes to achieve their respective goals for reducing oil and natural gas consumption while complying with environmental regulations without excessive costs. The Waste Management program has been directed at performing the required research and technology verification for dealing with the large quantities of solid waste products to enhance the environmental, economic, and social acceptance of the abundant coal resource as an energy source.

The FY 1987 program reflects completion in FY 1986 of several R&D projects and the continuation of the sampling and characterization of wastes from emerging technologies.

The coal fuel cycle presents a problem in that it produces a significant amount of waste. Some of these coal wastes are continually released to the environment as ash and leachate and the resulting effects are not fully understood. While the volume of residues from conventional technologies and those projected from emerging technologies pose a logistic problem, one of the most important unanswered questions centers around the degree of environmental hazard these residues represent. Research should provide answers which will aid the conventional coal consuming technologies to grow and accelerate the acceptance of new technologies. The three principal questions being addressed by the Waste Management program are:

- What, if any, are the potentially hazardous materials which are contained in and released from the wastes?;
- How are they released to the environment, or how do they occur?; and
- At what rate?

The answer to the first question will identify those wastes which may pose a hazard, but it will not be the deciding factor. The answers to the questions of how potentially harmful emissions occur, and at what rate, are the key to predicting the environmental impact of fossil energy waste disposal and developing control strategies. The principal thrust of the waste management program is directed towards:

- Sampling and characterization and basic data
- Energy recovery from coal preparation (cleaning) wastes.

Research into these areas will provide data for management of fossil energy wastes.

The proposed FY 1987 program will continue to build upon the waste management technology data base developed to date. Completion of the organics characterization of conventional fossil fuel combustion wastes during FY 1986 will permit limited work on sampling and characterization of the organics and inorganics of wastes from emerging fossil fuel use technologies. The sampling and characterization will continue to provide an understanding of waste characteristics and the physical, chemical and biological processes that release potentially harmful materials into the environment.

Anticipated FY 1987 accomplishments include:

- Continuing multi-year sampling and characterization of organic and inorganic compounds present in solid wastes from advanced coal technologies.
- Completing Phase I R&D for extracting energy from coal preparation wastes.
- Completing absorption and degradation studies of polynuclear (PAH) compounds in the soil.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
COAL
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Advanced research and technology development (FE)					
Direct utilization:					
Operating expenses	$ 9,990	$11,262	$11,262	$ 9,415	$ -1,847
Subtotal	9,990	11,262	11,262	9,415	-1,847
Materials and components:					
Materials					
Operating expenses	7,733	6,899	6,899	5,860	-1,039
Components					
Operating expenses	1,452	2,735	2,735	1,593	-1,142
Subtotal	9,185	9,634	9,634	7,453	-2,181
Technology crosscut:					
Environmental activities					
Operating expenses	2,459	2,345	2,345	2,200	-145
Technical and economic analyses					
Operating expenses	2,360	2,151	2,151	2,000	-151
Technology base synthesis					
Operating expenses	885	779	779	800	+21
Instrumentation, control, and diagnostics					
Operating expenses	1,500	2,056	2,056	1,356	-700
Subtotal	7,204	7,331	7,331	6,356	-975
University coal research:					
Operating expenses	4,425	5,622	5,622	4,000	-1,622
Subtotal	4,425	5,622	5,622	4,000	-1,622
Total					
Operating expenses	30,804	33,849	33,849	27,224	-6,625
Advanced research and technology development	$30,804[2]	$33,849	$33,849	$27,224	$ -6,625
Staffing Total FTE's: Direct ...	57	32	32	15	-17
Indirect .	29	22	22	19	-3

1/ Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

2/ Liquefaction processes, ($5.511M) and gasification processes ($3.364M) transferred from this activity to the Coal Liquefaction activity and Surface Coal Gasification activity, respectively.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer.	General Reduction	Gramm-Rudman-Hollings	Total
Advanced Research and Technology Development (FE)				
Direct Utilization				
Operating Expenses	$11,780	$-58	$-460	$11,262
Materials and Components:				
Materials				
Operating Expenses	2,861	-14	-282	2,565
Components				
Operating Expenses	7,216	-35	-112	7,069
Subtotal	10,077	-49	-394	9,634
Technology crosscut:				
Environmental activities				
Operating Expenses	2,453	-12	-96	2,345
Technical and Economic Analyses				
Operating Expenses	2,250	-11	-88	2,151
Technology Base Synthesis				
Operating Expenses	815	-4	-32	779
Instrumentation, Control, and Diagnosis				
Operating Expenses	2,150	-10	-84	2,056
Subtotal	7,668	-37	-300	7,331
University Coal Research				
Operating Expenses	5,884	-32	-230	5,622
Subtotal, Advanced Research and Technology Development..	$35,409	$-176	$-1,384	$33,849
General Reduction:				
Operating Expenses	-176	176	-	-
Total, Advanced Research and Technology Development	$35,233	-	$-1,384	$33,849
Operating Expenses	35,233	-	-1,384	33,849

Summary of Changes

FY 1986 Appropriation enacted	$33,849
Program increases and decreases:	
Direct Utilization	
o Decrease research in: deposition mechanisms; in-situ contaminant control; atmospheric and pressurized combustion phenomena; sulfur removal processes; molten carbonate and solid oxide electrochemistry; and fundamental beneficiation mechanisms	-1,847
Materials and Components	
o Materials - Reduce research in the areas of corrosion and erosion, alloy development, and structural ceramics development and characterization	-1,039
o Components - Decrease R&D on solids transport and novel component concepts	-1,142
Subtotal	-2,181
Technology Crosscut	
o Environmental activities - Decrease in the capability to conduct independent reviews and quality control of analytical tools and data bases under the Interagency Task Force on Acid Precipitation (ITFAP) program along with a decrease in analyses associated with air quality and water quality	-145
o Technical and economic analyses - Reduction in capability to improve the quality of analytic tools and data to perform technical/economic analyses of issues associated with potential fossil fuel utilization for the industrial and utility sectors	-151
o Technology base synthesis - Continue studies to identify fossil energy-related research needs and to order research priorities. Also, continue support to develop international cooperative research programs and technology exchanges	+21
o Instrumentation, control, and diagnostics - Reduce support for development of new measurement and control techniques to measure chemical and physical properties of process streams	-700
Subtotal	-975
University Coal Research	
o Decrease to about 20 the number of new university coal research projects relating to coal science, environmental science, surface science, organic and inorganic chemistry of coal constituents, and the mechanisms and kinetics of chemical reactions important to gasification, liquefaction and combustion	-1,622
FY 1987 budget request	$27,224

Advanced research and technology development:

Goals/Objectives:

The Advanced Research and Technology Development (AR&TD) Program is directed toward the scientific and technical areas that underlie the development of all fossil energy technologies. The program has been reoriented to respond to the critical fundamental research needs identified in recent years by the Energy Research Advisory Board, various Fossil Energy Research Working Groups, the National Academy of Sciences, and others. To assure continuation of the high quality research, program relevance, and scientific merit, a peer review of the AR&TD program was conducted in early 1984. The review was coordinated by DOE's Office of Energy Research and involved project assessments by experts from industry, National Laboratories, and academia.

The AR&TD coal science program focuses on mission-oriented fundamental research to increase understanding of the mechanisms of direct coal combustion. The AR&TD program also includes generic studies of materials and components and investigations of instrumentation concepts in environments associated with advanced coal technologies. Fundamental research at the Energy Technology Centers, National Laboratories, universities, and industrial and not-for-profit laboratories helps extend the scientific and engineering knowledge base and provides ideas for new processes and possible technical breakthroughs in coal conversion and utilization.

An important goal in each AR&TD subprogram is the discovery of new concepts and the small scale testing of these concepts for scientific and technical feasibility. AR&TD differs from the Fossil Energy line programs; the latter have an end-item technology development orientation. The AR&TD mission is to pursue generic research in support of all Fossil Energy coal line programs. It addresses fundamental scientific and engineering problems that are barriers to Fossil Energy technological goals. The AR&TD program is unique in that it is directed to specific scientific and technical areas which are closely connected to long-range Fossil Energy objectives. In contrast, DOE's Office of Energy Research principally supports basic research not specific to fossil energy technologies.

AR&TD research spans the spectrum of coal-related technologies of interest to the Fossil Energy line programs. The goals of this research are to:

- Increase the understanding of the fundamental principles that govern utilization processes;
- Understand the behavior of materials in coal-based systems;
- Conduct crosscutting research that benefits all coal technologies; and
- Provide a focus for supporting novel ideas related to fossil energy technologies.

Specifically, the objectives of AR&TD activities are to:

- Provide a focal point for governmental involvement in fundamental research on coal.
- Expand existing knowledge base, understanding, and verified modeling capability covering those chemical, physical, and thermodynamic phenomena critical to the design and performance of improved coal combustion systems.
- Explore innovative high risk, high potential payoff concepts for coal conversion and utilization.
- Provide a better understanding of the behavior of materials, components and instrumentation in environments associated with those expected to be found in advanced coal combustion and utilization systems.
- Continue the exploration of new materials, catalysts and electrolytes for fuel cell systems.
- Assess and coordinate environmental support for Fossil Energy programs.
- Coordinate the planning and development of a balanced Fossil Energy program.
- Coordinate, assess and plan Fossil Energy advanced research, including international and environmental activities.

To accomplish these objectives, the program is divided into the following functional areas: direct utilization, materials and components, university coal research, and technology crosscut. Technical direction is also provided for the advanced research activities in gasification and liquefaction.

Research is carried out by the Energy Technology Centers, the National Laboratories, universities, and industrial and not-for-profit laboratories.

FY 1986 Accomplishments:

In FY 1986, the AR&TD Program continued to conduct mission oriented fundamental research in the activities listed below:

- o Continued research on the determination of the physical and chemical properties of uncombusted coal-based fuels and solid, liquid and gaseous products produced during the combustion process.
- o Continued research in combustion science, including investigation of fuel injection, atomization, devolatilization and pyrolysis, volatile and char oxidation; the formation and transformation during combustion of pollutants (e.g., ash, alkali, sulfur and nitrogen compounds) and mass and energy transport, including support of the IEA-sponsored coal combustion science initiative.
- o Continued studies on deposition mechanisms before, during, and after combustion, with particular emphasis on ash, mineral matter, and alkalies in conventional and fluidized bed boiler, diesel engine, and gas turbine applications.
- o Continued research on processes relevant to coal beneficiation (e.g., comminution, extraction [illegible] sulfur, mineral matter, nitrogen and alkalies) and the control and removal of pollutants during and after combustion.
- o Continued generic electro-chemistry research pertinent to molten carbonate and solid oxide fuel cells.
- o Conducted research on high temperature corrosion, erosion, joining and mechanical properties of heat exchanger materials; reduced the level of effort on corrosion, erosion, and mechanical properties of structural ceramics and refractories.
- o Continued the assessment of unique seal techniques for severe process conditions and development of flow control concepts for hot multiphase gas.
- o Increased support for fundamental research in solids transport.
- o Conducted analyses associated with air and water quality, solid waste disposal, toxic substances, and supported occupational health and safety compliance services.
- o Continued research conducted by the Interagency Task Force on Acid Precipitation (ITFAP).
- o Continued funding of studies which support multi-year planning and Fossil Energy strategy and program formulation, technical/economic assessment studies that crosscut a number of Fossil Energy programs, and support of IEA/Coal Research Service.
- o Continued analyses, studies and technical evaluations in support of FE international activities and provided seed funding for new initiatives and identified advanced research needs.
- o Explored unique methods for measurement of multiphase flow parameters such as velocity, solids content, and viscosity; and for identifying chemical species by advanced methods such as plasma spectrographic techniques.
- o Initiated approximately 30 new university projects relating to coal science, environmental science, surface science, organic and inorganic chemistry of coal constituents and the mechanisms and kinetics of chemical reactions to gasification, liquefaction and combustion.
- o Initiated a cooperative agreement with the University of North Dakota Energy Research Corp. (UNDERC).

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Direct utilization	$11,262	$ 9,415	$ -1,847

This AR&TD subprogram conducts fundamental research to investigate and understand the basic underlying scientific principles that govern the behavior of coal utilization processes. Technology areas that benefit from this knowledge include: boiler, gas turbine and diesel engine applications employing conventional, fluidized bed and advanced combustion techniques; coal preparation and beneficiation, including coal-liquid and pulverized coal characteristics; fuel cells; hot gas cleanup for fuel cells, integrated gasifier and pressurized fluidized bed combined cycle power plants; flue gas cleanup of sulfur, particulate, nitrogen, alkali and trace element pollutants; and waste utilization. Activities are directed toward elucidation of the fundamental physical, chemical, biological and thermodynamic mechanisms inherent in coal utilization science, and include feasibility studies of advanced and novel concepts. A combination of experimental and theoretical research is employed in five major areas:

Properties - Determination of the physical and chemical properties of uncombusted coal, coal-based fuels, and the solid, liquid, and gaseous products produced during the combustion process.

Combustion Science - Study of the combustion process as it pertains to the technologies of interest in atmospheric, pressurized, and internal combustion systems, including investigation of fuel injection, atomization, devolatilization and pyrolysis, volatile and char oxidation; the formation and transformation of pollutants (e.g. ash, sulfur and nitrogen compounds); and mass and energy transport.

Deposition Mechanisms - Study of the mechanisms before, during, and after combustion, with particular emphasis on ash, mineral matter, and alkalies in conventional and fluidized bed boiler, diesel engine, and gas turbine applications.

Separation Processes - Study of the processes relevant to coal beneficiation (e.g. comminution, extraction of sulfur, mineral matter, nitrogen and alkalies) and the control and removal of pollutants during and after combustion.

Electrochemistry - Research on electrolytes, materials, catalysts and advanced fabrication techniques to develop more efficient and durable electrode structures and modeling and analysis capability pertinent to fuel cells.

Major emphasis in FY 1986 was concentrated on the following:

- Research on combustion kinetics and pyrolysis.
- Study of SO_x/NO_x formation in boilers.
- Study of novel means for pollutant (particulates, alkali, sulfur, nitrogen) removal in boilers.
- Research on coal preparation and beneficiation.
- Investigation of coal-liquid slurry rheology and atomization, particularly for non-utility advanced applications.
- Research on fluidized bed particle efflux and tube and wall wastage.
- Investigation of pressurized combustion and deposition mechanisms in advanced combustion concepts.
- Research on novel sorbents for hot gas sulfur compound separation.
- Electrochemistry and catalysis research concerning molten carbonate and solid oxide fuel cells.

The FY 1987 request of $9,415,000 represents a decrease of $1,847,000 from the FY 1986 funding level. At this decreased level, research in the area of properties will be continued at a level comparable with the FY 1986 effort. Research in combustion science, deposition mechanisms, separation processes, and electrochemistry will be continued, but at a reduced level of effort.

In FY 1987, efforts will include:

- Research on advanced pressurized and internal combustion processes applicable to gas turbines and diesel engines, concentrating on atomization and droplet disruption of coal-liquid mixtures, and mechanisms and kinetics of tar, ash and char production, devolatilization, and oxidation within the temperature and pressure profiles of these applications.
- Research on atmospheric combustion processes, concentrating on the mechanisms and kinetics of devolatilization and pyrolysis, the effects of beneficiation, radiative and convective heat transfer, and global char kinetics. This includes studies of low-rank coals and the effects of moisture, particle size, ash composition and alkali concentrations upon them.
- Research on advanced in-situ contaminant control of sulfur, nitrogen, ash and alkali compounds during the combustion process. This includes examination of specialized sorbents and the mechanisms and kinetics of pollutant formation and transformation, mass, momentum and energy transfer.
- Research on slagging and fouling from bituminous coals and increased research on slagging and fouling of low-rank coals, with emphasis on the mechanisms of deposition and the effects of beneficiation, atomization, particle size, and coal composition.

- o Research on novel/advanced processes for post-combustion emission control and innovative methods to control alkalies, nitrogen and sulfur oxides and ash at the atmospheric pressures of boiler flue gas cleanup systems and the elevated pressures of gas turbines.
- o Completion of a study on fluidized bed tube and wall wastage, concentrating on multi-phase particle efflux and erosion mechanisms.
- o Research on electrochemistry and catalysis of advanced fuel cells.
- o Research on coal surface chemistry and the behavior of liquid suspensions as it affects physical, chemical and biological means of separation of mineral matter, sulfur and nitrogen compounds in the preparation of clean coal fuels.

	FY 1986 Approp.	FY 1987 Request	Net Change
Materials and components	$ 9,634	$ 7,453	$ -2,181
Materials	$ 6,899	$ 5,860	$ -1,039

The AR&TD materials studies are directed toward understanding the behavior of materials used in coal-based energy systems. Conditions in coal liquefaction, gasification, combustion, and oil shale processing systems are considerably different from those in conventional energy systems. These advanced technologies encounter unusually high rates of sulfidation corrosion which is aggravated by erosion caused by solid matter. Similarly, high hydrogen partial pressures at higher than normal temperatures, in conjunction with sulfur species, present new aspects of hydrogen attack which are not well understood and must be studied. The significance of these materials problems is confirmed by the premature pilot plant shutdowns caused by material failures.

Typical projected accomplishments in FY 1986 include the following:

- o Comparison of non-destructive evaluation techniques for structural ceramics.
- o Initial assessment of the effect of processing parameters and microstructures on mechanical properties of ceramic-ceramic composites for fossil applications.
- o Continuation of research on joining of iron nickel-aluminides.
- o Continuation of a mechanistic study of the effects of deposits on corrosion of heat exchanger alloys.

Past AR&TD research was primarily directed toward identification of materials which functioned best in specific coal conversion environments. Current research is directed toward understanding the mechanisms of deterioration in situations common to a variety of fossil fuel applications. At the FY 1987 request level, all areas of materials research will be somewhat reduced. Specific activities in FY 1987 include:

- o Assess fracture and corrosion mechanisms in structural ceramics for coal applications.
- o Determine mechanisms of corrosion and corrosion erosion in fossil environments.
- o Collection and dissemination of information to the scientific community.

Components	$ 2,735	$ 1,593	$ -1,142

The goal of components research is to enhance industry's capability to produce reliable, efficient, versatile, and economic plants; it will be achieved through the study and development of advanced components concepts with potential for incorporation into operating systems and through development of fundamental data on process stream properties necessary for component design.

The design of coal-based synthetic fuel facilities and advanced utilization systems (process development units, pilot and commercial plants) is based on experience gained in conventional fossil fueled power plants and petrochemical facilities. The developers and operators of these new facilities experience excessive start-up periods, costly down-times, and expensive backup systems to achieve acceptable periods of operation because of component reliability.

The primary problem for components in fossil energy systems is the presence of solid materials in process streams. These solids increase wear, erosion, and fouling in pumps, valves, compressors, heat exchangers, filters, and other components.

The typical accomplishments expected in FY 1986 include:

- o Evaluation of the feasibility of a novel slurry pressure let-down device for use as a two-phase flow regulator, and initiation of three-phase tests.
- o Identification of mechanisms of wear in slurry seals.

In FY 1987, the program will continue to have two thrusts: the development of novel components concepts; and solids transport. Four novel components projects will continue in FY 1987: two assessing unique seal techniques for severe process conditions; and two evaluating slurry flow control devices.

The solids transport program was initiated in FY 1984. It consists of two major parts: research on bulk flow, which examines the fundamentals of solids, particularly coal, moving in chutes, hoppers and systems which feed storage bins and reactor vessels; and research on multiphase flow, which examines the fundamentals of flow situations in fossil conversion and utilization systems in which the solids are combined with liquids, or gases, or both. The ultimate objective of these basic studies, which involve modeling with experimental verification, is to improve the basis of components design.

In FY 1985 and 1986, implementation was begun on the recommendations of the planning workshop held during 1984. In FY 1987, the level of effort in this program will be reduced. The program focus will include:

- o Research to understand better the mechanisms of discrete particle flow.
- o Studies of the stability and rheology of suspension systems such as those occurring in coal-liquid mixtures.
- o Modeling and scaleup and design of suspension transport systems such as pneumatic coal slurry transport of solids.

	FY 1986 Approp.	FY 1987 Request	Net Change
Technology crosscut	$ 7,331	$ 6,356	$ -975
Environmental activities	$ 2,345	$ 2,200	$ -145

The FY 1987 request will provide funding for studies supporting Fossil Energy policy development and refinement, R&D assessment and compliance overview in the areas of environment, safety and health (ES&H). The principal analyses supporting policy development will focus on environmental issues related to fossil fuel use and the impacts on fossil energy resources and programs. This environmental effort will provide a policy and management framework for ensuring that ES&H considerations are properly integrated into Fossil Energy programs, and that projects and programs are conducted in compliance with ES&H laws and regulations. The requested funding will ensure that most ES&H compliance activities will be continued, and that the capability to conduct analyses of ES&H issues pertaining to air quality, and solid waste will be maintained. Of specific concern are the ES&H issues associated with emissions, and solid waste residuals. Also included in this request is funding for the research conducted by Task Group B (Manmade Sources) of the Interagency Task Force on Acid Precipitation (ITFAP). The Office of Fossil Energy chairs Task Group B.

Major functions of the environmental activities area include the 1) overview of programs to assure that facilities and projects comply with environment, safety and health legislation and regulations and 2) studies and analyses of broad issues that have the potential for affecting fossil energy resources and programs. These broad issues could arise from potential legislative and regulatory actions associated with laws such as the Clean Water Act, Resource and Conservation and Recovery Act, Toxic Substances Control Act, and the Clean Air Act. Studies and analyses are conducted with the objective of contributing to the formulation of Fossil Energy positions that are supported by technically accurate data. These studies are an important component of the Fossil Energy policy/planning process, which supports the formulation of Departmental positions and helps to identify new research areas with potentially high payoff. In conducting research in support of Task Group B and ITFAP, emphasis is placed upon studies that support the development of improved data on the nature and level of current and future emissions, particularly for presently uncharacterized species from fossil energy combustion and conversion processes. Accurate inventories of emissions of air pollutants relative to acid deposition, and quality assurance reviews of analytical procedures and uncertainties in emissions data bases by Task Group B are essential to the ability of ITFAP to produce critical assessments. The completion and subsequent revisions to the assessments are an important part of developing a rational, cost effective strategy for dealing with the acid rain problem.

Activities in FY 1986 include:

o Continue analysis of issues associated with air and water quality, solid waste disposal.
o Continue efforts on emissions modeling and data for the Interagency Task Force on Acid Precipitation.
o Continue to support occupational health and safety compliance services.

Similar activities will be continued in 1987 with some change in emphasis.

o Continuation of support of Interagency Task Force on Acid Precipitation. Limited effort will be focused on quality assurance of analytical tools and data bases.
o Continuation of support on occupational health and safety compliance services.
o Continuation of analysis of issues associated with air and water quality and solid waste disposal relative to impacts on fossil energy resources and technologies.

	FY 1986 Approp.	FY 1987 Request	Net Change
Technical and economic analyses	$ 2,151	$ 2,000	$ -151

The FY 1987 request will fund studies supporting multi-year planning and FE strategy and program formulation that are part of the continuing evaluation of Fossil Energy R&D priorities. Technical/economic analyses are needed to support Fossil Energy strategy and program development. These analyses provide a framework to ensure that Fossil Energy priorities are in accord with National goals and strategies, Department of Energy policies, and other important criteria relating to the appropriate federal R&D role. These funds will be utilized to conduct contract studies that crosscut a number of FE programs, such as the future replacement costs of liquid and gaseous fuels from conventional and nonconventional sources, and the analysis of various factors that may impact long-term fossil fuel use and the introduction of new fossil technology in the industrial, utility, residential/commercial and transportation sectors. It is expected that a number of important strategic planning issues requiring further analysis will be identified as a result of FY 1986 energy sector analysis efforts associated with the Interagency Task Force on Acid Precipitation and other major ongoing energy deliberations.

This subprogram also supports the International Energy Agency's London-based Coal Research Service (CRS). The CRS was formerly the Economic Assessment Service and the Technical Information Service which merged in 1984 in order to realize cost savings. It is a multilateral international project, jointly funded by 15 cooperating countries.

The functions of the CRS are the same as its predecessors, namely the consideration of the economics of future coal supply and use and the collection and dissemination of information related to all aspects of coal technology.

It is anticipated that activities supported in FY 1987 will be similar to activities in FY 1986 with modest reductions in scope due to lower funding, and include:

o Support multi-year planning and Fossil Energy strategy and program formulation studies.
o Fund technical/economic assessment studies that focus on major end-uses (e.g., transportation and industrial fuels) and thus crosscut a number of Fossil Energy programs.
o Support IEA/Coal Research Service studies, which will include studies in the areas of coal transportation, utilization and associated environmental issues.

	FY 1986 Approp.	FY 1987 Request	Net Change
Technology base synthesis	$ 779	$ 800	$ +21

This AR&TD subprogram provides overall integration and coordination of research and exploratory development activities that otherwise are often fragmented. It also provides an effective means of applying advances in one technology to the solution of problems in another. The coordination of Fossil Energy international activities is also supported by these funds.

Activities in FY 1986 focused on several important areas:

o Analyses, studies and technical evaluations in support of the International Energy Agency and bilateral/multinational agreements and activities in which the Fossil Energy Program is involved.
o Continuation or initiation of several advanced research projects of a multidisciplinary nature that are not easily accommodated by the current program due to their crosscutting nature.
o Identification of advanced research needs.

The FY 1987 request of $800,000 provides for crosscutting assessments and international coordination of Fossil Energy research. In addition, seed funding is also provided for novel, fundamental research projects.

Specifically, the following activities are expected in FY 1987:

o Development of an advanced research and technology development project fact sheet system which will provide a basis for program control, program integration and enable management to monitor more closely program execution.
o Initiate studies designed to assure that research being conducted in the Advanced Research and Technology Development (AR&TD) area is correctly focused and that it addresses the research needs of Fossil Energy technologies. This would include identifying areas where research gaps exist, identifying areas of overlapping research, if any, and serving as a basis for further integration of the AR&TD program.
o Conduct analyses, studies and technical evaluations in support of multilateral and bilateral international agreement activities in which the Fossil Energy program is involved.
o Continuation or initiation of several advanced research projects of a multidisciplinary nature that are not easily accommodated by the current program due to their crosscutting nature.

	FY 1986 Approp.	FY 1987 Request	Net Change
Instrumentation, control, and diagnostics	$ 2,056	$ 1,356	$ -700

Measurement of process parameters in fossil energy systems is essential to determination of the nature of a process stream and control of the process. Many critical parameters cannot yet be quantified so accurate design, measurement, and control are not possible. The basic cause is that process streams are multiphase, that is, they may contain solids, liquids, and gases in combinations that are not generally encountered in other systems. Research funded by the AR&TD instrumentation subprogram is directed toward the identification of techniques of measurement rather than development of functioning commercial instruments.

The projected accomplishments in FY 1986 are:

- o Preliminary identification of the limits of high resolution capillary column supercritical fluid chromotoography for fossil liquids.
- o Continued research on non-intrusive methods of measuring multiphase process stream parameters.
- o Continued research on a variety of techniques to measure chemical species in process streams.

At the reduced level of funding in FY 1987, the instrumentation, control and diagnostics program will concentrate on the development of techniques to identify chemical species peculiar to fossil systems. The use of laser-induced fluorescence spectroscopy to identify polynuclear aromatic hydrocarbons is an example of such a technique. The development of new instrumentation techniques is critical to the operation and control of advanced fossil systems.

University coal research	$ 5,622	$ 4,000	$ -1,622

The objective of the University Coal Research (UCR) Program is to support meritorious university projects in fundamental goal-oriented research related to all aspects of coal conversion and utilization that are of interest to the Fossil Energy program. However, unlike university projects supported by other Fossil Energy program elements, the University Coal Research projects are different in one or more of the following ways. University Coal Research projects:

- o tend to be longer range and more fundamental research, directed toward improved understanding rather than process improvement.
- o tend to be on crosscutting topics -- e.g., surface reactivity of coal powders, chemistry of mercury in coal hydrogenation and waste treatment, weathering effects on coal structure and reactivity, etc.
- o include student training as one of the project objectives.
- o are chosen from the top 10% of proposals received. Additional meritorious proposals have been offered to and accepted by other Fossil Energy programs.

The following accomplishments are representative of progress expected in FY 1986:

- o Development of improved nuclear magnetic resonance (NMR) techniques for investigating coal structure to determine the types of carbon-carbon and carbon-hydrogen bonds in various coals.
- o Investigation of fundamental processes involved in preparation of superclean coal by flotation of finely ground coals with bubbles/microbubbles of air, nitrogen, or carbon dioxide.
- o Determination of reactions of coal during supercritical extraction with water and organic solvents in the presence of hydrogen and catalysts.

In FY 1987, $4,000,000 is requested, compared with $5,622,000 appropriated in FY 1986. The FY 1987 request will allow for initiation of about 20 university projects compared with about 30 projects in FY 1986. The new grants will be awarded competitively through a Program Solicitation inviting proposals for fundamental research on coal in the areas of primary interest to the Fossil Energy Program. Topics of research will be selected with advice from mainline programs, and will include the following broad areas: coal science, surface science, mechanisms and kinetics, thermodynamics, solids transport and environmental science. Collaboration between university and industrial researchers will be encouraged.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
COAL
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Coal liquefaction (FE)					
Advanced research:					
Operating expenses	$ 5,511[2]	$ 5,157	$ 5,157	$ 2,620	$ -2,537
Subtotal	5,511	5,157	5,157	2,620	-2,537
Indirect liquefaction:					
Operating expenses	7,179	9,325	9,325	2,539	-6,786
Subtotal	7,179	9,325	9,325	2,539	-6,786
Direct liquefaction:					
Operating expenses	12,716	12,807	12,807	2,996	-9,811
Subtotal	12,716	12,807	12,807	2,996	-9,811
Support studies/engineering evaluations:					
Operating expenses	5,704	4,331	4,331	992	-3,339
Subtotal	5,704	4,331	4,331	992	-3,339
Total					
Operating expenses	31,110	31,620	31,620	9,147	-22,473
Coal liquefaction	$31,110	$31,620	$31,620	$ 9,147	$-22,473
Staffing Total FTE's: Direct ...	63	72	72	51	-21
Indirect .	22	27	27	22	-5

1/ Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

2/ Liquefaction processes ($5.511M) transferred to this activity from the Advanced Research and Technology Development activity.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer.	General Reduction	Gramm-Rudman-Hollings	Total
Coal Liquefaction (FE)				
Advanced Research				
Operating Expenses	$5,396	$ -28	$-211	$5,157
Indirect Liquefaction				
Operating Expenses	9,757	-51	-381	9,325
Direct Liquefaction				
Operating Expenses	13,399	-69	-523	13,199
Support Studies/Engineering Evaluations				
Operating Expenses	4,531	-23	-177	4,331
Subtotal, Coal Liquefaction ..	33,083	-171	-1,292	31,620
General Reduction:				
Operating Expenses	-171	171	-	-
Total, Coal Liquefaction (FE)	$32,912	-	$-1,292	$31,620
Operating Expenses	32,912	-	1,292	31,620
Capital Equipment				
Construction				

Summary of Changes

FY 1986 Appropriation enacted	$31,620
Program increases and decreases:	
Advanced Research	
o Research will be limited to work conducted at the Pittsburgh Energy Technology Center, the National Institute for Petroleum and Energy Research, and National Laboratories	-2,537
Indirect Liquefaction	
o Conduct research on catalysts and reactor systems at PETC. Eliminate university and reduce cost shared process oriented industrial research	-1,983
o Complete operations of the liquid phase methanol PDU at LaPorte, Texas	-4,803
Subtotal	-6,786
Direct Liquefaction	
o Complete operations of the Direct Coal Liquefaction Research facility at Wilsonville, Alabama	-6,140
o Continue bench scale process research only on existing contracts which will be completed in FY 1987	-2,352
o Restrict laboratory scale investigation of advanced process concepts to PETC in house research	-1,319
Subtotal	-9,811
Support Studies/Engineering Evaluations	
o Complete health effects and biomedical studies	-950
o Complete instrument and component research and research guidance studies	-1,488
o Complete data base management activities	-665
o Reduce laboratory research	-236
Subtotal	-3,339
FY 1987 budget request	$ 9,147

Coal liquefaction:

Program Summary

The FY 1987 budget request for the coal liquefaction technology base totals $9,147,000. The FY 1987 request supports fundamental and applied process research conducted primarily at the energy technology centers, National Labs and cost shared with industrial contractors.

Goals/Objectives:

The Coal Liquefaction program is structured to support the strategic objective established for FE "to increase the effective resource base for premium gas and liquid fuels through enchanced resource recovery and/or production of liquid and gaseous fuel analogs from coal, shale, and tar sands." The specific objective of the Coal Liquefaction program is to continue to add to the information base which supports development by the private sector of economical processes to convert U.S. coals to environmentally and technically acceptable liquid fuels. The program supports long term, potentially high payoff, basic and applied research and development.

Synthetic liquid fuels are an essential part of an energy scenario which provides the U.S. with the means, when required, to reduce reliance on imported petroleum, to have an answer as absolute supplies of petroleum eventually diminish and to increase the national security of energy supply. Coal is by far the largest fossil energy resource in the U.S. and preparation for its use as a longer term source of liquid fuels is essential as part of the U.S. energy strategy. Coal liquefaction technology, when combined with existing petroleum refining technology, will be able to provide direct replacement products for petroleum derived liquid fuels for heating and transportation. Research and development leading to innovative improvements in the present state-of-the-art will be necessary to improve the market potential of these technologies. With high uncertainty in supplies and prices in upcoming decades in the international petroleum market, the private sector will not undertake the long range, high risk R&D required to develop these improvements.

As the name suggests, direct liquefaction converts the complex organic chemical structures found in coal directly to liquid components by hydrogenation. This requires elevated temperatures and pressures and is almost always carried out in a liquid phase system containing powdered coal and a process derived pasting solvent. In coal/oil co-processing the pasting solvent is a petroleum fraction and therefore is also a feedstock to the process. This reduces or eliminates the need for recycle oil resulting in a much higher throughput for the same size plant, providing substantial reduction in capital cost per unit of output. The major potential advantages of direct liquefaction are high thermal efficiency, and high liquid product yield. The principal disadvantages stem from the severe operating conditions involving coal slurries and the high degree of integration found among process steps. The products have generally aromatic structures (in the chemical sense) because of the structures found in coal and this makes high quality motor gasoline a major product of direct liquefaction. The initial products may contain significant quantities of heteroatoms from the coal (most serious are nitrogen and oxygen) which must be removed by careful process adjustments or by known refining/upgrading treatments. Similarily, heavy aromatic compounds that are known to be biologically active may be present in direct liquefaction products, but these, too, can be reduced or eliminated by process adjustments or further processing.

The production of liquid fuels by indirect liquefaction involves coal gasification to produce a mixture of $CO + H_2$ (synthesis gas) followed by the catalytic conversion of the synthesis gas to liquids. The liquefaction (or synthesis) step is generally less complex from an engineering perspective than direct liquefaction but the overall process is generally less efficient and less selective to fuel grade liquids. The liquefaction step does not have to deal with coal ash and the liquid products which are free of sulfur and nitrogen contamination. The chemical structure of the products can favor production of diesel fuels as a major product. Biological activity and potential health effects are not likely to be a problem with the products of indirect liquid synthesis; the principal waste issues will be related to the synthesis gas production.

Inspection of the advantages and disadvantages of the two routes to liquid fuels from coal indicates that neither approach is clearly superior or preferable for development. The best products from each technology are different enough to suggest that both types of processes may be expected to coexist in any large-scale liquid synfuel industry. For these reasons a significant effort has been ongoing in each area.

In FY 1987, the Coal Liquefaction program continues to support basic and applied research to develop the scientific and engineering knowledge base with which industry can bring economically competitive and environmentally acceptable advanced technology for the manufacture of synthetic liquid fuels from coal into the marketplace when needed.

Specific objectives are to:

- Develop a better understanding of coal liquefaction processes, coal chemistry and related process engineering sciences.
- Expand the knowledge base on the physical, chemical and thermodynamic properties of fossil fuel liquids.

- Identify advanced, innovative improvements over state of the art processes for coal liquefaction which can utilize the entire U.S. coal base.
- Develop improvements in product selectivity and quality, and net yield of liquid products per ton of coal.
- Improve plant operability, on-stream factors, and process operating conditions to reduce capital and operating costs.
- Utilize synthesis gas produced by modern gasifiers from U.S. coals with a molar hydrogen to carbon monoxide ratio below one.
- Continue research on coal-oil co-processing using various coals, different oil stocks and operating conditions to provide data on the following improvements:
  - Cost savings possible through the simultaneous upgrading of coal and heavy oil.
  - Infrastructure advantages through introduction of coal into refining processes in an evolutionary fashion.

FY 1986 Accomplishments:

Advanced Research

- Continued exploration of novel coal liquefaction process concepts, including biological approaches.
- Continued research to obtain a better understanding of coal liquefaction and reactions of synthesis gas.
- Continued research on application of new and evolving concepts in catalysis to coal liquefaction.
- Continued research on the physical, chemical and thermodynamic properties of fossil fuel liquids.

Indirect Liquefaction

- Completed operation and data acquisition from methanol to gasoline (MTG) pilot plant in collaboration with West Germany using prior funding.
- Continued to emphasize laboratory research to provide data which will broaden the knowledge of catalyst and reaction systems.
- Completed research on liquid phase methanol synthesis with operation of and data acquisition from the PDU at La Porte, TX.

Direct Liquefaction

- Continued laboratory and bench scale research on co-processing heavy oil and coal.
- Continued bench scale research on the close coupled direct catalytic process.
- Completed proof-of-concept testing of staged liquefaction at Wilsonville.
- Continued exploratory studies on new process technology including in-house studies.

Support Studies/Engineering Evaluations

- Completed biomedical studies with emphasis on products from co-processing coal and residual petroleum and from advanced staged liquefaction processes.
- Completed research guidance studies and instrument and component research.
- Completed liquefaction data base management activities. Focused on analysis and consolidation of data, including some modeling.
- Continued laboratory research in support of process studies. Emphasis on solvent characterization, reaction kinetics and catalyst characterization and deactivation mechanisms.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Advanced research	$ 5,157	$ 2,620	$ -2,537

The main focus of this program is small scale, fundamental phenomenological studies in coal liquefaction. Research areas include catalysis and kinetics and mechanisms of indirect liquefaction. Other studies leading to advanced liquefaction concepts include hydroextraction of coal, the effects of specific solvent components on kinetics and liquefaction products, and biological approaches to coal liquefaction.

In addition, this program consolidates and augments scientific research on the physical, chemical, and thermodynamic (PCT) properties of fossil fuel liquids. It is responsive to the often identified need to improve the fundamental understanding and existing information base on liquid properties related to synthetic fuels processing. The ultimate goal is to develop simple predictive techniques for identifying PCT properties of fossil fuel liquids relevant to synthetic fuel technologies.

The Advanced Research (AR) liquefaction activity is significantly different from the other line liquefaction subprograms in the following ways:

More fundamental - The AR program supports research on correlation of coal properties with reactivity for liquefaction. Examples include nuclear magnetic resonance (NMR) probing of coal and coal-solvent interactions; investigation of the structure of low rank coal; acquisition of physical, chemical, and thermodynamic (PCT) data on coal liquids; and the Penn State Coal Sample Bank. The other subprograms have little or no such activities. Information from this research aids the other line subprograms by providing fundamental information and data to assist in improvement of coal liquefaction processes.

Higher risk and more exploratory - The AR program supports high risk approaches to coal liquefaction such as electrochemical and biological methods, and the use of supercritical extraction and unconventional solvents. Characteristically, the economics of these approaches are not known. AR approaches that show promise may be expected to "graduate" to the other line subprograms.

Smaller scale - AR projects are invariably conducted on a small scale, not involving continuous units and not above a laboratory scale.

Typical projected accomplishments in FY 1986 include the following:

- Completion of initial evaluation of several microorganisms for biological liquefaction of coal.
- Investigation of the synthesis and evaluation of novel, highly active catalytic materials based on hydrous oxide support materials that offer unusual versatility for catalyst formulation.
- Elucidation of chemical pathways for hydrogen consumption and redistribution under different coal liquefaction conditions.
- Quantification of structural features of low rank coal.
- Selection and maintenance of a group of 50 coal samples representative of U.S. coal resources to provide high quality coal samples and related compositional data to coal researchers.
- Measurement of accurate PCT data on organic sulfur and nitrogen compounds that are models for substances found in coal derived liquids.

In FY 1987, $2,620,000 is requested, a decrease of $2,537,000 from the FY 1986 funding level. Research will be continued at the Pittsburgh Energy Technology Center, the National Institute for Petroleum and Energy Research, and National Laboratories. The research efforts will continue on the properties of coal liquids and reaction mechanisms during the coal liquefaction process. Limited industrial and university research on novel catalytic, biological and other coal liquefaction processes will continue. Research will also continue on the physical, chemical and thermodynamic properties of fossil fuel liquids.

	FY 1986 Approp.	FY 1987 Request	Net Change
Indirect liquefaction	$ 9,325	$ 2,539	$ -6,786

The FY 1987 funding request for Indirect Liquefaction is $2,539,000, a decrease of $6,786,000 from the FY 1986 funding level. This decrease can be attributed to new program policy guidelines directing Fossil Energy R&D efforts away from proof-of-concept and industrial research and towards in-house research studies. Specific changes to this program are the elimination of the LaPorte liquid phase methanol PDU project and reorientation of catalyst and reactor studies to in-house work at PETC while continuing certain cost shared industrial research projects.

Indirect liquefaction is a technology which can produce by catalytic synthesis a variety of liquid fuels, including gasoline, distillate fuels and furnace oils, and alcohols, from gaseous feedstocks. These products are suitable for virtually all U.S. market sectors including the transportation, residential, industrial/commercial and utility markets. The DOE program has as its primary objectives the following:

- achieving more selective and economic liquid fuel yields, and
- achieving better utilization of coal-derived (low hydrogen content) gas feedstocks.

To accomplish these objectives, major emphasis is placed on improved reactor systems and advanced catalysts because these contribute most to the yields, economics, and feed flexibility of indirect liquefaction processes.

A commercial (Fischer-Tropsch) process was first conceived during the 1930's to convert low carbon monoxide content gas to a broad range of liquids. While evolutionary improvements have been made, the commercial process still has inherent limitations. A major limitation is the production of large quantities of by-product chemicals for which there is no significant market in the U.S.

The broad based research program now in place is effectively investigating the technology for converting the high carbon monoxide content (low ratio H_2/CO) synthesis gas produced by the modern gasifiers, including those marketed by U.S. industry, to quality fuels. Current research is emphasizing homogeneous catalysts and heterogeneous catalysts with shape selectivity and bi-functional capabilities. The new technology eventually will selectively produce the desired, high quality fuels without the extensive downstream processing required in the past. Reactor designs which are necessary to provide close control of the reaction temperature and recover the exothermic heat of reaction are a part of the program.

The indirect liquefaction program in FY 1986 emphasized the study of advanced catalysts and chemical reactions. The methanol to gasoline (MTG) pilot plant also completed operations in West Germany using FY 1984 funds. This facility is supported equally by DOE, the West German government, and industry. The MTG plant demonstrated the versatility of the basic process concept by producing olefins from methanol. The olefins can be converted to high quality diesel fuel in an existing process, thus providing an efficient route for the production of diesel fuel, as well as gasoline, from methanol. PETC continued basic studies of the direct synthesis of liquid fuels including catalyst composition, preparation, activation techniques and slurry phase reactions. A number of laboratory scale research projects were also underway with industrial and university organizations to investigate catalysts and reaction mechanisms in order to improve product selectivity and yields. Reactor designs including gas fluidized three phase systems were under development.

Research to investigate the concept of producing methanol in a slurry phase reaction from carbon monoxide rich synthesis gas continued. This liquid phase methanol concept could provide electric utilities a valuable option at advanced, combined cycle power plants. Some of the coal derived synthesis gas will be converted to liquid methanol to be available as a fuel for peak electricity generation. Unconverted gas will be a turbine fuel for base load use.

In FY 1987, the indirect liquefaction subprogram will continue laboratory research to provide data for better understanding catalyst and reaction systems which permit the direct utilization of coal derived synthesis gas to produce high quality gasoline, distillate or alcohol fuels selectively. This research will be conducted at PETC and at some industrial facilities under existing contracts.

	FY 1986 Approp.	FY 1987 Request	Net Change
Direct liquefaction	$12,807	$ 2,996	$ -9,811

This subactivity has supported the development of innovative improvements that have the potential for yielding significant cost reductions in direct liquefaction technologies. Based on previous research, feasible improvements have been identified and the Direct Liquefaction subprogram has conducted research to exploit these improvements by evaluating process concepts that offer potential for lower hydrogen consumption, higher liquid yields, higher quality products, and greater flexibility in feed coal and product slate selection. Elements of the program have included catalyst development and evaluation, laboratory and integrated bench scale process research, and proof-of-concept evaluations at a 6 ton per day scale at Wilsonville, Alabama. In FY 1987 the program will be reoriented to an in-house technology base program conducted at Pittsburgh Energy Technology Center. Several existing industrial research contracts ending in FY 1987 will be completed.

Process development activities for near term direct liquefaction technologies are considered technically ready for larger scale demonstration by the private sector. Proof-of-concept testing of the staged liquefaction process was completed at Wilsonville in FY 1986. A substantial data base on this newer process concept is now available over a range of conditions with both bituminous and subbituminous coals. No funds are requested for Wilsonville in FY 1987.

Based on a competitive multiyear award two cost-shared industrial projects have been evaluating the co-processing of coal with heavy oil since October 1984. The objective is to evaluate the technical feasibility and establish a process data base on this concept. Co-processing is a new concept in coal liquefaction that offers the potential for substantial cost reduction and for acceleration of the introduction of coal-derived fuels into the marketplace by utilizing to a greater extent existing petroleum refinery technology and equipment. The work completed to date has established the technical feasibility of the process. Screening work completed in FY 1985 showed that high coal conversions and good liquid yields can be obtained using U.S. bituminous and subbituminous coals with a number of U.S., Canadian, and other imported crude oils. Preliminary continuous bench scale studies in FY 1986 will establish operating performance over a range of operating conditions. In FY 1987 each project will be completed with additional bench scale studies and preparation of a preliminary conceptual design.

Bench scale testing of a close coupled catalytic direct liquefaction process was continued in FY 1986 to develop improvements in process performance and economics. In FY 1987 this project will be completed with further bench scale research and preparation of a preliminary conceptual design.

A number of laboratory activities in the technology base and screening test area being carried out under contracts with industry and universities will be completed in FY 1986 and no additional funds are requested for this activity.

Funds are being requested to continue in-house, technology base research at PETC. The PETC projects are focused on new direct liquefaction process concepts and analytical studies to improve understanding of coal liquefaction reaction mechanisms and catalysts. In FY 1987, at least three areas will be pursued: (1) studies of coal conversion catalysts; (2) co-processing of coal with heavy oil; and (3) use of non-conventional chemical systems in Direct Liquefaction. If available, evaluations of technology data from the Japanese will also be conducted.

In FY 1986 an international agreement for R&D research between DOE and Italy was initiated which includes a laboratory scale project in liquefaction. This project will continue in FY 1987.

	FY 1986 Approp.	FY 1987 Request	Net Change
Support studies/engineering evaluations	$ 4,331	$ 992	$ -3,339

This subactivity supports the overall coal liquefaction program and includes studies applicable to all of the technologies under development. The studies have included independent technical status reviews for research guidance, instrument and component research, environmental and technological R&D, and generic laboratory research supportive of process research. Data management has also been included with emphasis on capture of the information from the previous large scale projects and modeling studies to make data available and useful to industry. In FY 1987 this subactivity will be reoriented to a technology base program in liquefaction research conducted at Sandia National Laboratory. An industrial contract in technology base research will also be continued.

Certain fractions of coal-derived liquids have produced toxic effects in laboratory animals. A technology oriented health effects (biomedical) test program is underway which is coordinated with the health effects program of the Office of Energy Research. Undesirable components are characterized and efforts made to evaluate techniques to reduce toxic materials in a manner compatible with liquefaction processes. Previous work has provided assessment of material from two-stage liquefaction processes and initial tests on co-processing products. Long term skin painting studies continued to evaluate various levels of hydrotreatment to destroy bioactive substances. Data developed in the program can be used by industry to identify process configurations or operating conditions needed to minimize production of toxic substances. This activity will be completed in FY 1986.

Research and development has been needed to help improve critical mechanical components and controls identified as problem areas for pilot and commercial scale operations. Past projects provided significant advances in slurry pump operation and slurry metering instrumentation. In FY 1986, work was continued in deashing feed monitoring instrumentation and solvent quality enhancement and measurements. Funds are requested for this work in FY 1987 to complete one industrial research project on instrumentation.

In FY 1986, efforts were continued on generic laboratory research in support of the process research activities, such as experimental studies on catalyst deactivation mechanisms, process solvent characterization, and reaction kinetics and mechanisms. In FY 1987, work will continue on developing improved understanding of kinetic effects of importance to advanced liquefaction processes along with work on solvent and catalyst characterization techniques.

In prior years, work has been supported in liquefaction information management activities. The objective of this project has been to develop and implement an information management system to collect, evaluate and disseminate liquefaction research and development data from past large scale operations. In FY 1985, data acquisition activities were completed for the major liquefaction project activities (SRC-II, H-Coal, EDS). In FY 1986, efforts were focused on further analysis and consolidation of this data as well as adding data from advanced process research activities to the information base. This project will be completed in FY 1986.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
COAL
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 1/ Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Combustion systems (FE)					
Atmospheric fluidized bed combustion:					
Operating expenses	$18,737	$16,572	$16,572	$ 1,590	$-14,982
Subtotal	18,737	16,572	16,572	1,590	-14,982
Pressurized fluidized bed combustion:					
Operating expenses	2,458	5,061	5,061	3,686	-1,375
Subtotal	2,458	5,061	5,061	3,686	-1,375
Advanced combustion technology:					
Operating expenses	1,967	3,409	3,409	1,882	-1,527
Subtotal	1,967	3,409	3,409	1,882	-1,527
Alternative fuels:					
Operating expenses	6,930	4,071	4,071	2,011	-2,060
Subtotal	6,930	4,071	4,071	2,011	-2,060
Total					
Operating expenses	30,092	29,113	29,113	9,169	-19,944
Combustion systems	$30,092	$29,113	$29,113	$ 9,169	$-19,944
Staffing Total FTE's: Direct ...	34	24	24	20	-4
Indirect .	24	24	24	19	-5

1/ Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer.	General Reduction	Gramm-Rudman-Hollings	Total
Combustion Systems (FE)				
Atmospheric Fluidized Bed Combustion Operating Expenses	$17,341	$ -92	$-677	$16,572
Pressurized Fluidized Bed Combustion Operating Expenses	5,296	-28	-207	5,061
Advanced Combustion Technology Operating Expenses	3,569	-21	-139	3,382
Alternative Fuels Operating Expenses	4,257	-20	-166	4,071
Subtotal, Combustion Systems..	$30,463	$-161	$-1,189	$29,113
General Reduction:				
Operating Expenses	-161	161	-	-
Construction				
Total, General Reductions				
Total, Combustion Systems (FE)	$30,302	-	$-1,189	$29,113
Operating Expenses	30,302	-	-1,189	29,113

Summary of Changes

FY 1986 Appropriation enacted	$ 29,113
Program increases and decreases:	
Atmospheric Fluidized Bed Combustion	
o Complete funding of TVA demonstration project in FY 1986	-14,334
o Complete advanced concept bench scale testing	-762
o Continue special application PRDA to be issued in FY 1986	+299
o Discontinue coal characterization (LRC) studies and economic design follow-on. Continue in-house research on particle motion flow, erosion, bed internals and heat transfer surfaces	-185
Subtotal	-14,982
Pressurized Fluidized Bed Combustion	
o Complete cost-shared program with industrial sector for high efficiency advanced PFB concepts following completion of Phase I systems definition studies	-695
o Complete testing of advanced hot gas cleanup devices at New York University and continue test program to obtain data on combustion characterization heat transfer and provide a basis for advanced concept designs	-169
o Complete metals wastage studies on the mechanisms and kinetics of coal/sorbent combustion products, materials survivability, etc., in a PFB environment and terminate experimental testing program to verify laboratory testing	-480
o Reduce in-house research effort on PFB dynamics, data analysis, and engineering/systems analysis	-31
Subtotal	$ -1,375
Advanced Combustion Technology	
o Complete efforts associated with the AVCO advanced slagging retrofit combustor project	-765
o Complete Phase I efforts. Phase II efforts will be initiated at a reduced effort	-255
o Continue in-house activities supportive of generic advanced combustion technology	-74
o Complete funding of the AVCO pulsed combustor project	-433
Subtotal	-1,527
Alternative Fuels	
o Reduced the scope of light industrial/commercial applications PRDA for detailed combustion and fuel handling characterization R&D for CLM/micropulverized coal fuels in selected light industrial and commercial furnaces/boilers	-2,060
FY 1987 budget request	$ 9,169

Combustion systems:

Goals/Objectives:

The goal of the Combustion Systems activity is to increase the contribution and application of the nation's coal resources through the development of acceptable combustion systems and fossil-derived fuels for the marketplace. The programs within the overall Combustion Systems activity are Atmospheric Fluidized Bed, Pressurized Fluidized Bed, Alternative Fuels and Advanced Combustion Technology.

The objective of the AFB program is to broaden the market and utilization of coal by expanding the technology application to the light industrial, commercial/institutional and residential sectors in an economical and environmentally acceptable manner. While there are 19 U.S. manufacturers of AFB's, the units are competitive with oil and gas only in the 150,000 pound of steam per hour sizes and larger. The smaller units installed in the light industrial sector are economically competitive only on a case-by-case basis, i.e., cogeneration, high capacity, supplemental waste fuel, etc. This program will develop generic AFB's for the entire market that compete economically and environmentally with oil and gas.

The Pressurized Fluidized Bed Combustion program objective is to establish the technology which will enable industry to demonstrate and commercialize first entry systems by the early 1990's and to extend the technology by developing data for advanced PFB concepts which provide quantum improvements in system efficiency and substantial reductions in the cost of electricity.

The objective of the Advanced Combustion Technology program is the development of technology that will permit the use of coal in boiler, furnace and heater applications now using oil or natural gas. This would include the retrofit of existing equipment as well as the design of new systems to optimize the use of the new technology developed.

The Alternative Fuels program objective is to establish the technology for light industrial/commercial/residential combustion systems that defines the ability of those systems to technically, economically, environmentally, and socio-aesthetically accommodate coal liquid mixtures and other coal-based fuels as a means of displacing the oil and/or natural gas presently consumed by those systems.

FY 1986 Accomplishments:

Atmospheric Fluidized Bed Combustion

- Completed operations of the East Stroudsburg and Wilkes-Barre AFB units.
- Completed economic system studies of advanced concepts and initiated bench scale construction and testing.
- Completed funding support of the 160 MW TVA demonstration plant.
- Continued economic studies of critical cost elements, conducted coal characterization studies/burn tests (LRC) and in-house erosion research.
- Award contracts for special applications PRDA.

Pressurized Fluidized Bed Combustion

- Continued testing at NYU to obtain data on performance of advanced hot gas cleanup devices.
- Completed the laboratory experiment program to evaluate erosion/corrosion of PFB materials (in-bed tubes, gas turbine blades).
- Continued in-house research on data and engineering/system analysis.
- Initiated a cost shared follow-on effort to test key critical PFB process components, i.e., tube bundle, CWM slurry feeding, hot gas cleanup.
- Initiated Phase I of cost shared program with industry for advanced PFB systems with improved economic and high efficiency.

Advanced Combustion Technology

- Completed the Advanced Slagging Combustor project (TRW).
- Initiated PRDA for coal fired systems for light industrial, commercial/institutional and residential applications.
- Completed AVCO slagging combustor project including tests on the bench scale unit.
- Initiated in-house testing on coal fired units with varying air fuel ratios and coal based fuels for emissions characterization and market sector application.
- Completed AVCO pulsed combustor project.

Alternative Fuels

- Defined the "suitability" and "extent" of continued characterization R&D for specific combustion system configurations for light industrial/commercial and residential boiler/furnace applications of CLM/micro-coal fuels.
- Continued emissions characterization to address effluents/intrusions from CLM use.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Atmospheric fluidized bed combustion	$16,572	$ 1,590	$-14,982

The objective of the AFB program is to broaden the market and utilization of coal by expanding the technology application to the light industrial, commercial/institutional and residential sectors in an economical and environmentally acceptable manner. While there are 19 U.S. manufacturers of AFB's, the units are competitive with oil and gas only in the 150,000 pound of steam per hour sizes and larger. The smaller units installed in the light industrial sector are economically competitive only on a case-by-case basis, i.e., cogeneration, high capacity, supplemental waste fuel, etc. This program will develop generic AFB's for the entire market that compete economically and environmentally with oil and gas.

FY 1986 funds were utilized to complete economic systems studies and commence bench scale testing of Advanced Concepts; initiate bench scale designs of Special Applications; continue coal characterization studies/burn tests (LRC); continue economic studies of critical cost elements; continue fluidization research and complete funding support of the TVA 160 MWe demonstration project.

FY 1987 funds will be utilized to complete designs and initiate construction and testing of the most promising of the special application bench scale units and conduct basic in-house research on particle motion flow, erosion, bed internals and heat transfer surfaces.

Pressurized fluidized bed combustion	$ 5,061	$ 3,686	$ -1,375

The pressurized fluidized bed (PFB) combustion program objective is to develop PFB combustion systems that achieve high combustion efficiency and acceptable component durability and reliability while staying within acceptable emission levels. The goal of DOE sponsored activities is to develop PFB scientific and engineering technology data through proof-of-concept to support private sector efforts to demonstrate and commercialize first entry PFB systems for electric power generation in the 1990 time frame.

In FY 1986, the follow-on effort was initiated at the Grimethorpe facility to develop data on combustion efficiency, hot gas cleanup performance, coal water slurry feeding and performance of an updated heat exchanger design. This effort is cost shared with the British National Coal Board, EPRI and United States industry. Additionally, the New York University facility completed operations to obtain data on advanced hot gas cleanup devices. The PFB Advanced Concepts (second generation) program was initiated as a cost-shared effort with industry to develop systems which would offer significant improvements in process economics, reliability, operability and environmental performance.

The FY 1987 funds will be utilized to continue the Grimethorpe follow-on test program on hot gas clean-up, coal water slurry feeding and performance of updated heat exchangers. Efforts at NYU will be continued to evaluate components and design changes to enhance performance and provide the basis for advanced concepts. The METC effort would continue research and development support of the first generation systems development including component evaluation and combustion performance characterization as well as testing of in-house PFB reactors (both hot and cold) to develop paramters that affect particle movement and impingement on heat exchanger surfaces. These efforts are being directed towards providing the technical data needed by industry to demonstrate first generation combined cycle and turbocharged systems. Additionally, efforts would be completed for the first phase of the Advanced Concepts program which would define the system, identify technology development needs and provide a conceptual design of an advanced PFB electric power plant. Finally, funding will be used for the Advanced Concept program by initiating the second phase efforts for development and testing those key critical process components which would impede commercialization. The Advanced Concepts (Second Generation) program would develop systems which provide a quantum leap in cycle performance (increase efficiency 40% to at least 45%) and substantial reductions in the cost of electricity (reduce cost by at least 20% over conventional coal-fired systems with flue gas desulfurization). The Advanced Concepts program goal is to provide the technology at sufficient scale to enable industry to proceed with pilot scale testing by the mid to late 1990's.

	FY 1986 Approp.	FY 1987 Request	Net Change
Advanced combustion technology	$ 3,409	$ 1,882	$ -1,527

The objective of the Advanced Combustion Technology program is to develop the equipment which will enable existing oil and gas fired boilers, furnaces and process heaters to be retrofitted to burn coal or coal-water mixtures (CWM). This activity is also concerned with the development of new or innovative concepts that will extend the use of coal to smaller commercial and residential markets. The technology development will be applicable to the design of new systems that have the advantage of versatility, environmental cleanliness, and acceptable economics as compared to boilers that utilize conventional direct coal combustion.

In FY 1986, efforts were concentrated on the completion of Phase I of the AVCO Slagging Combustor Project, testing and evaluation of the TRW Slagging Combustor, and a novel pulsed combustor (AVCO) study contract. Conceptual designs and bench scale testing of these innovative combustion concepts were completed. In addition, the light industrial concepts RFP planned for FY 1985 was redirected and combined with an FY 1986 PRDA for commercial and residential concepts. This PRDA resulted in the award of contracts and initiation of Phase I activities (economic and environmental assessments) in FY 1986. At PETC, an in-house effort was initiated in FY 1986 to investigate SO_x and NO_x emissions at varying air/fuel ratios. Studies related to dense phase transport of solids and fuel characterization were performed. Data collected from these activities were organized and archived at PETC.

The FY 1987 request will be used to continue the development of Light Industrial, Commercial, and Residential concepts selected from the FY 1986 PRDA. This will include the design, fabrication, and installation of hardware and some operational testing. Generic in-house activities supportive of these projects will continue at PETC, including fuel characterization efforts and the operation of small size combustors to study NO_x and SO_x emission at varying air/fuel ratios. Dense phase transport studies and the collection and management of data will continue.

Alternative fuels	$ 4,071	$ 2,011	$ -2,060

FY 1987 represents a change in program direction towards a more limited Federal role in support of long-term, high-risk R&D. Therefore, the FY 1986 budget is addressed as a transitional period from the current product development/proof-of-concept philosophy with varying levels of possible Federal support to basic technology research areas with specified maximum percent levels of Federal support.

As a result of this redirection, FY 1986 funds will be used to address the use of CLM fuels in residential applications, and the planned PRDA to examine the use of these fuels in the light industrial/commercial sectors will be reduced in scope to be completed in FY 1987 with FY 1986 funds.

The objective of the alternative fuels activity is to provide the technology development necessary to establish a technology base for retrofitting coal-liquid mixtures to existing oil and gas designed facilities with emphasis on coal in slurry form. The R&D effort will generate a data base sufficient for private sector assessment as to the commercial acceptability of these coal-based fuels for their site specific needs in both retrofit and new capacity applications.

In FY 1986, funds were used for generic combustion characterizations to identify specific light industrial, commercial and residential combustor configurations having a high technical potential for CLM and/or micro-pulverized coal fuel use; and to define a detailed combustion characterization R&D activity for those units adequate to yield the quality and quantity of data required for private sector use and decision.

FY 1987 funds will be used to complete detailed combustion and component characterization R&D for CLM/micro-pulverized coal fuels in selected existing light industrial, commercial and residential boiler/furnace systems. Also, detailed technical, economic, environmental and socio-aesthetic assessments on the use of CLM fuels in these systems will be completed. The specific characterization R&D and assessment efforts will render detailed documentation for private sector use that identifies/determines the adequacy of the selected equipment to accommodate CLM/micro-pulverized coal fuels.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
COAL
FOSSIL ENERGY RESEARCH AND DEVELOPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1/] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Fuel cells (FE)					
Phosphoric acid systems:					
Operating expenses	$28,573	$20,355	$20,355	$ ...	$-20,355
Subtotal	28,573	20,355	20,355	...	-20,355
Molten carbonate systems:					
Operating expenses	8,851	9,932	9,932	3,400	-6,532
Subtotal	8,851	9,932	9,932	3,400	-6,532
Advanced concepts:					
Operating expenses	3,048	3,770	3,770	1,600	-2,170
Subtotal	3,048	3,770	3,770	1,600	-2,170
Total					
Operating expenses	40,472	34,057	34,057	5,000	-29,057
Fuel cells	$40,472	$34,057	$34,057	$ 5,000	$-29,057
Staffing Total FTE's: Direct ...	0	0	0	0	0
Indirect .	13	11	11	5	-6

1/ Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer.	General Reduction	Gramm-Rudman-Hollings	Total
Fuel Cells (FE)				
Phosphoric Acid Systems Operating Expenses	$21,300	$-113	$-832	$20,335
Molten Carbonate Systems Operating Expenses	10,400	-62	-406	9,932
Advanced Concepts Operating Expenses	3,942	-18	-154	3,770
Subtotal, Fuel Cells	$35,462	$-193	$-1,392	$34,057
General Reduction: Operating Expenses	-193	193	-	-
Total, Fuel Cells (FE)	$35,449	-	$-1,392	$34,057
Operating Expenses	35,449	-	1,392	34,057

Summary of Changes

FY 1986 Appropriation enacted	$34,057
Program increases and decreases:	
Phosphoric Acid Systems	
o Complete all funding for development of the 11MW and 7.5 MW electric utility systems, on-site water-cooled and dielectric cooled systems and leave full responsibility to the private sector for any further development and application of these technologies	-20,355
Molten Carbonate Systems	
o Continue the development of external reforming and internal reforming fuel cell stacks. Continue efforts to develop improved components and corrosion resistant materials for molten carbonate cells	-6,532
Advanced Concepts	
o Continue research and development of solid oxide technology and critical materials	-2,170
FY 1987 budget request	$ 5,000

Fuel cells:

Goals/Objectives:

The objective of the Fuel Cells program is to support high risk, high payoff technology base development and to assist private industry in developing hydrocarbon fuel conversion technologies to increase the cost effective, efficient and environmentally acceptable use of conventional and alternative hydrocarbon fuels. The Administration position is that this objective will have been achieved for phosphoric acid systems by the end of FY 1986 and full responsibility will be left to the private sector for further development and application of phosphoric acid fuel cell technologies. The International Fuel Cell Corp. (IFC), a partnership of United Technologies and Toshiba of Japan, has already announced plans to market 11 MW systems based on the DOE-funded design.

Fuel cells are electrochemical (not combustion/Carnot cycle-limited) conversion systems which are highly efficient (40 to 60 percent), fuel-flexible, modular, and environmentally attractive energy conversion systems.

Potential fuel cell applications include electric utility multi-megawatt power plants (with or without cogeneration) and on-site multi-kilowatt cogenerating systems, transportation applications to include railroad, marine, trucks and buses (which represent 35 percent of oil consumption in transportation), defense applications including remote radar stations and stationary facilities, marine and submarine systems, and mobile power supplies with low infrared and noise signatures.

Fuel cell power plants can be sited at the point of both electrical and thermal energy need of stationary applications. With the power plant installed on-site, the heat produced by the plant while generating electricity can help meet the thermal needs of the consumer with reduced distribution and transmission losses. Fuel cells offer an energy conversion choice of interest to a broad sector of the economy. They have the potential of generating electricity with a wide spectrum of fuels including synthetic liquids (methanol, etc.), natural gas, and gases from coal, biomass and waste.

First generation phosphoric acid fuel cells potentially can be used in the following applications: electric utility dispersed peaking, intermediate and spinning reserve, building total energy systems, waste fuel recovery (e.g., industrial waste hydrogen, anaerobic digestors, and solid waste), industrial cogeneration, and defense applications. Because of their inherent advantages and potential, private industry has a strong incentive to support the development and commercialization of phosphoric acid fuel cells.

Advanced second generation molten carbonate and solid oxide fuel cells potentially can be used in: electric utility intermediate, baseload, on-site integrated energy systems and industrial cogeneration applications. These advanced fuel cell power plants can be integrated with coal gasifiers and can be bottomed with a steam or a gas turbine delivering electricity at approximately 50 percent efficiency (coal pile to busbar). Advanced fuel cell technical development trails behind phosphoric acid development but provides a potential of increased efficiency and reduced cost. It is therefore still an appropriate target for Federal support.

The technical feasibility of phosphoric acid fuel cells utilizing clean fuels (i.e., natural gas) has been established by testing preprototype systems in excess of 200,000 operating hours (cumulative hours on about 40 power plants to date). Emphasis has been on technology improvement to reduce the cost and increase the power density and endurance of phosphoric acid power plants, and to verify the operational feasibility in on-site and electric utility applications. The technical feasibility of molten carbonate fuel cells operating at approximately 60 percent electrical conversion efficiency (natural gas to busbar) has been forecasted by single cell testing. The complexity and associated capital costs of advanced fuel cell systems are projected to be less than those for first generation systems.

Solid oxide electrolyte fuel cells have the advantage of solid state stability and have been projected to be more easily manufactured. The operating temperature of 1800°F allows a highly efficient bottoming cycle with projected power plant efficiencies of approximately 50 percent.

FY 1986 Accomplishments:

Phosphoric Acid Systems
o Continued technology development of water-cooled on-site systems; performed verification tests of prototype stack and plant subsystems.
o Initiated testing of 25 kW on-site system including dielectric-cooled stack, fuel processor and inverter.
o Continued inverter and stack technology work on the 11 MW water-cooled electric utility system through development of stack configuration "B".
o Continued electric utility R&D with air-cooled stacks for a 7.5 MW system; began tests of 25 kW stacks and tests of 100 kW engineering model stack.
o Continued a small activity for analytical evaluations in support of the above development efforts.

Molten Carbonate Systems
o Completed verification testing of first external reforming, large area short stack.
o Completed Energy Research Corporation's direct fuel cell technology in small cells.
o Initiated PRDA for further development of external and/or internal reforming stacks.
o Initiated development of a contaminant resistant fuel cell capable of processing gases containing sulfur and chlorine.
o Continued system studies and research on cell corrosion and electrode stability.
o Continued studies at ANL on new cathode materials and supporting research.

Advanced Concepts
o Continued R&D effort at Westinghouse with fabrication and initial tests of 5 kW preprototype module.
o Continued system studies and research on cell materials, cell fabrication techniques and evaluation of new concepts.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Phosphoric acid systems	$20,355	$ ...	$-20,355

The Department is requesting no FY 1987 funding for phosphoric acid fuel cell development and proposes that further development be solely the responsibility of the private sector.

The objective of the phosphoric acid fuel cell program through FY 1986 has been to develop the technology for electric utility and on-site systems so that the private sector can demonstrate and commercialize powerplant systems in the post-FY 1986 time period. The program has been cost shared with the Electric Power Research Institute (EPRI), the Gas Research Institute (GRI), manufacturers and participating utilities.

In prior years, research and development efforts on phosphoric acid fuel cells have resulted in the demonstration of forty six 40 kW on-site fuel cell powerplants in gas utility service. Research and development funding has also provided for continuing the development of follow-on (higher power level) advanced, on-site powerplants which the private sector expects to commercialize in the 1987-1988 time period. Phosphoric acid fuel cell research and development efforts have also provided the technology verification of pressurized, large area (120 psia, 10 ft^2) fuel cell stacks for a commercial prototype 11 MW system, and early development of the cell and stack for an alternate 7.5 MW system.

FY 1986 funds were utilized to continue development of a water-cooled on-site system with verification testing of a prototype stack and plant subsystems as well as to continue development of a dielectric-cooled on-site system with testing of a 25 kW unit including stack, fuel processor and inverter. FY 1986 funds were also utilized to continue development of inverter and stack technology applicable to an 11 MW water-cooled electric utility system through development of stack configuration "B", as well as to continue development of a 7.5 MW system with tests of 25 kW and 100 kW stacks. Supporting analytical evaluations effort was continued at a low level.

The phosphoric acid fuel cell technology has, as a result of these developments and demonstrations, reached a maturity level such that the private sector can now assume full responsibility for the continuation of development and commercialization of this technology. No activities are proposed in FY 1987.

Molten carbonate systems	$ 9,932	$ 3,400	$ -6,532

The FY 1987 budget request will continue FY 1986 research activities at a reduced level of effort in the areas of external and internal reforming molten carbonate fuel cell stacks, cell components, and corrosion resistant materials. The private sector would be expected to assume a larger role in further development of molten carbonate fuel cell systems.

The objective of the molten carbonate fuel cell program has been to develop an advanced, high performance fuel cell technology for electric utility and industrial cogeneration applications. The technology would have the capability of using conventional hydrocarbon fuels such as natural gas or coal-derived gas. The program has been cost shared with EPRI.

In prior years, research and development efforts have resulted in the demonstration of short (20 cell) stacks and the initial verification of internal fuel reforming in single cells. A research effort has also been conducted to model the effects of sulfur contaminants on cell performance.

FY 1986 funds were utilized to continue technology activities associated with cell contaminants, corrosion mechanisms and mechanical deformation of stacks. FY 1986 funds were also utilized for the completion of development and test verification of an external fuel reforming, full area short stack and internal fuel reforming technology in small stacks. A PRDA was issued in FY 1986 for the further technology development of full area and full height internal and external reforming fuel cell stacks.

The technical feasibility of molten carbonate fuel cells has been demonstrated in small stacks in laboratories. In FY 1987, research will continue to develop internal and external reforming fuel cell stacks. Efforts will also continue to develop improved components and corrosion resistant materials for molten carbonate fuel cells.

	FY 1986 Approp.	FY 1987 Request	Net Change
Advanced concepts	$ 3,770	$ 1,600	$ -2,170

The FY 1987 budget request will continue FY 1986 research activities at a reduced level of effort in the testing of a 5 kW module and the development of a 25 to 200 kW generator. No additional funding is requested beyond FY 1986 for the completion of system studies and research on solid oxide fuel cell materials. The private sector would be expected to assume a larger role in further development of solid oxide fuel cell concepts.

The objective of the advanced concepts program has been focused on the technology development and verification of solid oxide fuel cells. The solid oxide fuel cell is an advanced, high temperature (1800°F) solid state fuel cell that offers promise in electric utility and in cogeneration applications (because of the high temperature) in industrial and commercial sectors. The program has been cost shared with the manufacturer.

In prior years, research and development efforts have focused on the fabrication and test verification of single cells and modules of 12 to 24 cells.

FY 1986 funds were utilized to continue technology development of a tubular solid oxide fuel cell concept including the fabrication and initial test of a 5 kW module and the initial design of a 25 to 200 kW generator.

The technical feasibility of solid oxide fuel cells have been demonstrated in small modules in laboratories. In FY 1987, efforts will be continued to develop solid oxide technology as well as critical materials research. Specifically, research efforts will continue the development of the 25 to 200 kW generator.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
COAL
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1/] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Heat engines (FE)					
Operating expenses	$11,850	$12,314	$12,314	$ 7,942	$ -4,372
Subtotal	11,850	12,314	12,314	7,942	-4,372
Total					
Operating expenses	11,850	12,314	12,314	7,942	-4,372
Heat engines	$11,850	$12,314	$12,314	$ 7,942	$ -4,372
Staffing Total FTE's: Direct ...	6	7	7	6	-1
Indirect .	10	9	9	8	-1

[1/] Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy
FY 1987 Congressional Budget Request
Adjustments to FY 1986 Appropriations

	FY 1986 Confer.	General Reduction	Gramm-Rudman-Hollings	Total
Heat Engines (FE)				
Operating Expenses	$12,886	$-69	$-503	$12,314
Subtotal, Heat Engines (FE) ..				
General Reduction: Operating Expenses	$ 69	69	-	-
Total, Heat Engines (FE)	$12,817	-	$-503	$12,314
Operating Expenses	12,817	-	-503	12,314

Summary of Changes

FY 1986 Appropriation enacted	$12,314
Program increases and decreases:	
Heat Engines	
o Continue research activities, at a reduced level, related to the FY 1985 PRDA for coal fired gas turbine major systems component development to provide selected integrated systems test validations by a target date of 1990-1992. Continue coal fired diesel engine component design and evaluation program and initiate research activities related to the FY 1986 PRDA for diesel engine integrated test validation	-4,372
FY 1987 budget request	$ 7,942

Heat engines:

Goals/Objectives:

The principal goal of this program is to establish technical data which will enable the private sector to assess the commercial viability of coal-fueled power conversion systems. The program focuses on key technical problems associated with substituting coal or coal-derived gaseous fuels for distillate fuels or natural gas in gas turbine and diesel power conversion systems. The program goal is to assist the private sector, through selected research efforts, to develop the technology needed for direct firing of coal, either dry or suspended in a liquid carrier, or a coal-derived gaseous fuel cleaned at minimal cost.

Specific program objectives are to:

- o Establish component design, fuel specification, and operating requirements for coal fueled gas turbine power systems and determine, through integrated systems tests, the commercial feasibility of selected system concepts in specific railroad, marine, industrial, or utility applications.
- o Establish basic design, combustion, materials, and fuel interactions and related engineering data to facilitate private sector assessment of commercial viability of coal-fired diesel systems through integrated systems tests.

FY 1986 Accomplishments:

- o Initiated research activities, at a reduced level, related to FY 1985 PRDA for coal fired gas turbine major system component development to provide selected integrated systems test validations by a target data of 1990-1992. The contracts to be structured so as to allow completion of specific portions of the work commensurate with available funds.
- o Continued economic and technical studies by diesel manufacturing firms of potential coal-fired diesel power systems in specific railroad or industrial service. Based on results, formulated general requirements for integrated engineering development of selected system concepts.
- o Established technical feasibility of slagging combustor design concepts and/or sorbent injection approaches to extract deleterious impurities from the combustion gases produced by selected coal fuels.
- o Completed report requested by Congress on feasibility of coal-fired locomotive.
- o Initiated PRDA for coal-fired diesel engine integrated systems test validations.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Heat engines	$12,314	$ 7,942	$ -4,372

The FY 1987 budget request will continue FY 1986 research activities at a reduced level of effort.

The Heat Engines program is directed towards major engineering design, durability, and performance problems associated with the substitution of coal or coal-derived fuels for distillate fuels and natural gas in gas turbine and diesel power conversion systems. This fuel substitution creates technical problems in both types of engines. In turbines, the durability of major components (i.e., combustors, transition ducts and turbine airfoils) are of concern. Similarly, the hostile environments created by firing coal-based fuels affect the durability of diesel engine components, particularly cylinder walls, pistons, valves and injectors. In addition, both applications require adjustments of combustion component design and conditions to suppress NO$_x$ emissions and to ensure efficient combustion of coal-based fuel.

Activities under the Gas Turbine Program are being coordinated and directed towards definitive integrated systems testing, targeted for the 1990-1992 time period. Major component design, development, and integrated test evaluation will be conducted by qualified industrial contractors. Essential engineering research and analytical support relating to fuel specifications, design analyses, environmental concerns, and quality control considerations are being carried out in DOE and national laboratories or by qualified university and private sector research organizations. Coal-derived gaseous fuels, coal-liquid slurry fuels, and dry powdered coal are all being evaluated under the program. The integrated systems tests are expected to provide a firm basis for private sector commercial development of power systems for such applications as railroad locomotives, industrial cogeneration, or utility combined cycle power generation.

The Diesel Program is planned similarly to reach the integrated systems test phase in the 1992-1994 period. Following preliminary analytical studies and experimental feasibility testing, major diesel manufacturers will be solicited to competitively or cooperatively develop and test, integrally, essential power system components. Supporting activities will be conducted in a manner similar to the gas turbine approach. The program aims toward eventual rail locomotion and industrial cogeneration applications.

FY 1987 anticipated accomplishments include:

- Continue combustion tests in the gas turbine combustor test stand to determine combustion characteristics of various fuels and the establishment of preliminary coal fuel specification.
- Continue combustion and wear tests utilizing coal liquid mixtures in the new "in-house" diesel engine test facility at METC.
- Initiate research activities related to the FY 1986 PRDA for the coal-fired diesel engine integrated systems test validation.
- Complete preliminary coal-fueled testing of diesel test facility components including fuel injection system, combustion chamber, and piston assemblies.
- Complete engineering tests to determine the feasibility of slagging combustors and sorbent additions.
- Complete first portion of the coal-fired gas turbine integrated systems test validation program.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
COAL
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1/] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Underground coal gasification (FE)					
Gasification technology development:					
Operating expenses	$ 3,098	$ 2,352	$ 2,352	$ ...	$ -2,352
Subtotal	3,098	2,352	2,352	...	-2,352
Environmental and advanced research:					
Operating expenses	2,607	1,720	1,720	...	-1,720
Subtotal	2,607	1,720	1,720	...	-1,720
Total					
Operating expenses	5,705	4,072	4,072	...	-4,072
Underground coal gasification	$ 5,705	$ 4,072	$ 4,072	$ ...	$ -4,072
Staffing Total FTE's: Direct ...	0	0	0	0	0
Indirect .	13	9	9	0	-9

[1/] Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

BEST COPY AVAILABLE

Department of Energy
FY 1987 Congressional Budget Request
Adjustments to FY 1986 Appropriations

	FY 1986 Confer.	General Reduction	Gramm-Rudman-Hollings	Total
Underground Coal Gasification (FE)				
Gasification Technology Development Operating Expenses	$2,460	$-12	$-96	$2,352
Environmental and Advanced Research Operating	1,800	-10	-70	1,720
Subtotal, Underground Coal Gasification (FE)	4,260	-22	-166	4,072
General Reduction: Operating Expenses	-22	22	-	-
Total, Underground Coal Gasification (FE)	$4,238	-	$-166	$4,072
Operating Expenses	4,238	-	-166	4,072

Summary of Changes

FY 1986 Appropriation enacted	$ 4,072
Program increases and decreases:	
Gasification Technology Development	
o Phase out technology base activities and initiate applied research under the cooperative R&D venture pool	-2,352
Environmental and Advanced Research	
o Phase out technology base activities and initiate applied research under the cooperative R&D venture pool	-1,720
FY 1987 budget request	$ ...

Underground coal gasification:

Goals/Objectives:

Underground Coal Gasification (UCG) is a process for converting coal, in place (in situ), to a readily cleanable synthetic gas comparable to that produced from surface gasification systems. The energy for the process is derived from partial combustion of the coal (pyrolysis) resulting in the identical reactions that occur in aboveground gasification. The process is being developed to address the coal resources considered unminable for either economic or technical reasons, e.g., steeply dipping, high ash, deeply buried, or high sulfur coals. Advantages of the technology include low front end capital requirements, short lead time required to establish a plant in operation, relative freedom from the usual economies-of-scale considerations, utilization of less desirable coals, the ability of the process to convert all the sulfur in the coal to readily removable "acid-gas" (Hydrogen sulfide), and the ability to produce a wide variety of end use products. As to the latter, gasification with air produces a low Btu gas (100-175 Btu/SCF) suitable for power generation or industrial heat while gasification with an injection mixture of steam and oxygen produces a medium Btu gas (175-350 Btu/SCF) either for the same uses or as a chemical feedstock for the production of methanol, ammonia, or for upgrading to a suite of products.

A series of tests at varying scale have been conducted over the past several years on UCG. The process was essentially proven for steeply dipping (greater than 35 degrees) shrinking subbituminous coals through a cost shared field development program with the Gulf R&D Company. Some questions remain regarding application of UCG to flat lying subbituminous coals prior to an industry takeover of the final stages of development. Answers essential to this next step along the R&D path are being sought through a three year program begun in FY 1985. These technology base activities will be completed in FY 1987. Application of UCG to bituminous coals represents a greater technological challenge primarily because it swells and tends to choke off gas flow required to link injection and production wells. In addition, bituminous coals usually occur in thinner seams which present a more difficult drilling and linking target and compound thermal losses during operation. Preliminary testing has proven encouraging, however, and Peabody Coal Company (with support from the State of Illinois) has agreed to participate in a cooperative program to explore the potential of UCG in bituminous coals at a site in southern Illinois. Paralleling the subbituminous and bituminous process research is an environmental program concerned primarily with preventing or predicting and mitigating the effects of aquifer contamination and subsidence. Empirical models developed for subsidence prediction appear adequate at this time but an understanding of aquifer contamination mechanisms and mitigation or clean up measures must be developed if UCG is to be deemed an environmentally acceptable technology. The approach will be to address these issues in concert with planned cooperative ventures. Also, there is need to perform certain monitoring activities at previous test sites to comply with Federal and state laws (funding requirements in this regard are declining as sites are declared acceptable and abandoned).

Because of the inherent advantages of UCG discussed above, there is a high degree of international interest in the technology. This interest has allowed us to leverage our resources through cooperative programs with two countries to date: (1) We have an agreement with Brazil to collaborate on planned developments there with the U.S. receiving data from field tests; and (2) We have received approval and funding from the U.S./Spain Joint Science and Technology Committee for a joint research project with Spain which will provide valuable data on bituminous UCG. Other countries have expressed a desire to work with DOE. This interest will be aggressively pursued under the cooperative R&D venture pool.

The major objectives of this program are the following:

- Pursue the development of environmentally acceptable in situ technologies for converting coals which are unattractive to mine into clean liquid or gaseous fuels.
- Demonstrate the viability of producing medium-Btu gas from low-rank coals utilizing steam/oxygen, to provide a suitable feedstock for surface upgrading and/or combustion.
- Test the viability of underground gasification of low to moderate swelling, bituminous coals.
- Increase the data base to support private sector development of economically viable in situ conversion processes.
- Work actively with industry to ensure maximum technology transfer.
- Actively seek opportunities to leverage project funds for process development activities through cooperative projects with industry and with foreign research and development groups studying UCG.

FY 1986 Accomplishments:

FY 1986 accomplishments include:

- Completed second year of a three year effort to establish a technology base for application of UCG to subbituminous coals sufficient to launch industrial process development.
- Completed a series of large-block tests on WRI's large laboratory reactor to test feasible concepts and determine operating mechanisms in support of the field programs.
- Completed necessary monitoring data receipt and advising as needed in cooperating with early UCG efforts in Spain, Brazil, India and Yugoslavia.
- Completed essential post-burn monitoring and evaluation of past UCG test sites.
- Completed on-going laboratory and test site research directed toward aquifer restoration methods and contaminant mitigation procedures along with the completion of a predictive model for migration of potential contaminants after operation and development of a plan for aquifer clean-up if this should prove necessary.
- Completed further development of process models to assist industry in plans for follow-on development of the processes.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Gasification technology development	$ 2,352	$ ...	$ -2,352

No funds are requested in FY 1987 for this program. A three year effort initiated in FY 1985 to develop a technical data base requisite to industrial process development will be concluded using previously appropriated funds. Follow-on research and development activities will be pursued through potential cooperative ventures with industry.

Environmental and advanced research	$ 1,720	$ ...	$ -1,720

The reduction in funding from the FY 1986 level reflects completion of environmental data base development activities in part through the three year program discussed above and through parallel laboratory and field testing conducted by the Lawrence Livermore National Laboratories and the Western Research Institute.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
COAL
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1/] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Magnetohydrodynamics (FE)					
Proof-of-concept topping cycle:					
Operating expenses	$18,344	$18,302	$18,302	$ ...	$-18,302
Subtotal	18,344	18,302	18,302	...	-18,302
Proof-of-concept bottoming cycle:					
Operating expenses	8,500	8,024	8,024	...	-8,024
Subtotal	8,500	8,024	8,024	...	-8,024
Proof-of-concept seed regeneration:					
Operating expenses	600	388	388	...	-388
Subtotal	600	388	388	...	-388
System studies and supporting research:					
Operating expenses	3,277	1,003	1,003	...	-1,003
Subtotal	3,277	1,003	1,003	...	-1,003
Total					
Operating expenses	30,721	27,717	27,717	...	-27,717
Magnetohydrodynamics	$30,721	$27,717	$27,717	$ ...	$-27,717
Staffing Total FTE's: Direct ...	0	0	0	0	0
Indirect .	12	0	0	0	0

[1/] Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer.	General Reduction	Gramm-Rudman-Hollings	Total
Magnetohydrodynamics (FE)				
Operating Expenses	$29,000	$-150	$-1,133	$27,717
Subtotal, Magnetohydrodynamics (FE)	$29,000	$-150	$-1,133	$27,717
General Reduction: Operating Expenses	-150	150	1,133	-
Total, Magnetphydrpdynamics (FE)	$28,850	-	$-1,133	$27,717
Operating Expenses	28,850	-	-1,133	27,717

Summary of Changes

FY 1986 Appropriation enacted	$27,717
Program increases and decreases:	
Magnetohydrodynamics	
o Terminate the MHD program	-27,717
FY 1987 budget request	$ ...

Magnetohydrodynamics:

Goals/Objectives:

The Department believes that the cost of continuing its MHD program is not affordable in light of current fiscal constraints and has reassessed its priorities for fossil energy technologies and determined that other technologies could contribute more directly to DOE's objectives with lower investment requirements, in a more timely manner, and with significantly more cost-sharing. We believe that the private sector interests that have promoted MHD are in a position to continue to develop MHD technology based on the Federal Government's efforts to date. The private sector can continue the MHD program with an-in-kind contribution by the Government of facilities and equipment valued at approximately $120 million.

FY 1986 Accomplishments:

- Completed eight-hour (nominal) integrated combustor-channel power generation test at the CDIF.
- Completed testing of baghouse and electrostatic precipitator at the CFFF.
- Awarded cost-shared seed recovery/regeneration contract and initiated bench-scale testing.
- Awarded cost-shared contract for feasibility and conceptual design study of a coal-fired MHD retrofit.
- Awarded cost-shared contract for an integration/mission contractor.
- Awarded cost-shared contract for a prototypical 50MW (thermal) coal-fired combustor.
- Awarded cost-shared contract for a prototypical long-duration channel.

Budget Request:	FY 1986 Approp.	FY 1987 Request	Net Change
Magnetohydrodynamics	$27,717	$ ...	$-27,717

The Department requested no funding in FY 1986 assuming that the MHD program would be terminated in FY 1985. However, Congress overturned the Department's proposed FY 1985 deferral stipulating in the Conference Report of July 2, 1985, that "the managers expect the MHD community to develop and submit to the appropriate Congressional committees a plan for significant industry cost-sharing which would include increasing commitments above existing levels. The new cost-sharing plan should be based on the MHD development plan submitted by the Department to Congress in June 1984. Additional funds should not be appropriated absent increased cost-sharing."

Bill language for FY 1986 provides $28,850,000 to fund a cost-shared, multi-year MHD program. The costs of fabricating equipment to be tested in the Government-owned facilities are to be included in the amounts that require cost sharing. The costs of installing and testing equipment are not to be subject to cost sharing.

No funds are requested for FY 1987. The transition of the MHD program activities from the Congressionally directed FY 1986 activities to termination will be addressed as part of subsequent FY 1986 budget proposals. It is anticipated that the large amount of equipment and facilities having significant value and owned by the Government can be made available to private industry in a manner that will allow industry to continue the development of the technology consistent with their interests and funding availabilities.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
COAL
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Surface coal gasification (FE)					
Advanced research:					
Operating expenses	$ 3,364[2]	$ 3,379	$ 3,379	$ 968	$ -2,411
Subtotal	3,364	3,379	3,379	968	-2,411
Advanced process development:					
Operating expenses	4,376	5,229	5,229	1,689	-3,540
Subtotal	4,376	5,229	5,229	1,689	-3,540
Systems engineering concepts:					
Operating expenses	20,878	27,949	27,949	1,373	-26,576
Subtotal	20,878	27,949	27,949	1,373	-26,576
Environmental and engineering analyses:					
Operating expenses	3,516	2,113	2,113	1,131	-982
Subtotal	3,516	2,113	2,113	1,131	-982
Great plains coal gasification project:					
Operating expenses	3,000	2,653	2,653	437	-2,216
Subtotal	3,000	2,653	2,653	437	-2,216
Total					
Operating expenses	35,134	41,323	41,323	5,598	-35,725
Surface coal gasification .	$35,134	$41,323	$41,323	$ 5,598	$-35,725
Staffing Total FTE's: Direct ...	20	23	23	18	-5
Indirect .	41	37	37	43	+6

1/ Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

2/ Gasification processes ($3.364M) transferred to this activity from the Advanced Research and Technology Development activity.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

BLANK PAGE

BLANK PAGE

BLANK PAGE

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer.	General Reduction	Gramm-Rudman-Hollings	Total
Surface Coal Gasification (FE)				
Advanced Research Operating Expenses	$ 3,535	$-18	$-138	$3,379
Advanced Process Development Operating Expenses	5,472	-2[illegible]	-214	5,229
Systems Engineering Concepts Operating Expenses	29,243	-152	-1,142	27,949
Environmental and Engineering Analyses Operating Expenses	2,212	-13	-86	2,113
Great Plains Coal Gasification Proj. Operating Expenses	2,775	-14	-108	2,653
Subtotal, Surface Coal Gasification (FE)	$43,237	$-226	$-1,688	$41,323
General Reduction: Operating Expenses	-226	226	-	-
Total, Surface Coal Gasification (FE)	$43,011	-	$-1,688	$41,323
Operating Expenses	43,011	-	-1,688	41,323

Summary of Changes

FY 1986 Appropriation enacted	$41,323
Program increases and decreases:	
Advanced Research	
o Complete advanced research in the areas of gas separation techniques and kinetics of coal gasification. Reduce research in the areas of fundamental chemistry and reaction mechanisms, and the chemistry of ash and slag from gasifiers	-2,411
Advanced Process Development	
o Redirect effort to focus only on the support of those studies specifically generating data required to establish the feasibility of advanced and novel techniques leading to the use of coal gasification technology in the generation of alternate energy options from coal	-3,540
Systems Engineering Concepts	
o Complete all efforts on projects that are being supported to generate reliability, availability and maintainability (RAM) and proof-of-concept (POC) data. In addition, redirect all studies that are considered to be engineering development efforts by nature	-26,576
Environmental and Engineering Analyses	
o Conclude all projects now being supported in waste water management and in the generation of data on other environmental aspects of coal gasification that are either available through the judicious extrapolation of the data base or which are or will be generated through the operation of existing coal gasification facilities (e.g., Great Plains Coal Gasification Plant, Cool Water, Dowsyn, Kilngas, etc.)	-982
Great Plains Coal Gasification Project	
o Reduce monitoring and management activities	-2,216
FY 1987 budget request	$ 5,598

Surface coal gasification:

Goals/Objectives:

The coal resource base of the United States is the largest single potential source of alternate hydrocarbon liquids and gases available to resolve anticipated energy supply problems of the Nation. As a heterogeneous SOLID feedstock, the full potential of this resource can be achieved only if it can be converted into useable alternate LIQUID AND GASEOUS energy products and chemical feedstocks.

The role that the Surface Coal Gasification Program serves in accomplishing the goals and objectives of the Office of Fossil Energy and the Department of Energy is to develop the full capabilities of coal gasification technology as a means of converting coal into those alternate energy forms that do create options for almost every sector of the energy consuming marketplace.

The research approach to the development and use of the most appropriate, efficient, and advanced concepts suitable for use in accomplishing that goal recognizes and accommodates the wide range in requirements of that marketplace. While that marketplace requires an almost unlimited number of coal gasification systems to respond to the specific needs of the consumer, (the availability of resource type, specific site requirements, etc.), the research and development program recognizes that each of these many systems can be grouped into one of several major classes. These classes include systems for the production of power, industrial fuel gas, synthesis gas and coproducts or new fuels. The advances in the technology required to formulate and use these systems are being developed in research and development projects that are considered to be long-range and high-risk with objectives particularly suited to resolving the major issues and problems encountered in developing new promising alternatives for each of the separate processing units of these systems. Included among these units are feedstock modification, gasifier performance, particulate removal and heat recovery, acid gas removal and composition control, as well as fuel conversion and product upgrading. Completion of these activities will create the maximum number of options by which the energy consuming marketplace can use coal to fill its energy requirements.

In these activities R&D efforts are now focused on the acquisition of data leading to a further understanding of the gasification process and the functional links between that process and the operational parameters that will permit:

- o the state of the technology to remain current with those advances being made in associated fields and to be responsive to any advanced processing system designed to accommodate a changing market for fuels
- o development of any new concepts that appear to be 'break throughs' which have significant potential to improve the technology or contribute to its application in generating energy supply options
- o confirmation of the chemistry, kinetics and thermodynamics of the gasification process required to confirm, extend and apply advanced concepts leading to a fuller utilization of the total flexibility of the process

Successful completion of these activities will achieve the two major goals of the Surface Coal Gasification program.

These specific program goals which have been established to insure that the program creates options responsive to the requirements of those sectors of the U.S. economy that can use the technology to generate alternate energy products from coal are:

- o Advance the state-of-the-art of Surface Coal Gasification technology to optimize its potential for development of more viable or advanced gasification systems through the study of promising long term, high risk concepts that have significant potential to:
  - increase overall system efficiency
  - reduce capital costs
  - reduce system operating costs
  - reduce facility construction time
  - increase plant availability
  - reduce to a minimum the potential for any environmental impact caused by these facilities.

- o Identify and support those R&D efforts that will make available the full capabilities and processing flexibility of surface coal gasification systems as the key coal conversion technology directly applicable for generating alternative energy options from coal for every sector of the energy consuming marketplace.
- o Continue management and monitoring of the Great Plains Gasification Demonstration Project as necessary.

FY 1986 Accomplishments:

- o Completed slip stream testing studies.
- o Completed the cooperative operational program investigating reliability, availability, and maintainability (RAM) characteristics of the Allis-Chalmers KILnGAS Coal Gasification Demonstration Facility.
- o Completed a cooperative program investigating the pressurized ash agglomerating fluidized-bed coal gasification integrated system for combined cycle electric power production or other industrial uses (including hot gas cleanup and hot particulate removal as part of the integrated system).

- Continued to provide engineering analyses and systems evaluation as required to support activities of the joint DOE/GRI Coal Gasification Program.
- Completed testing of the CO_2 triple point crystallizer and sulfur absorber sections of the liquid CO_2 gas cleanup system.
- Concluded the electroslag component casting project and demonstrated its capability for producing high quality, low cost equipment castings.
- Concluded the instrumentation project for measuring gas stream alkali particulates composition.
- Concluded the atomic absorption instrumentation project for measuring gasifier product gas stream composition.
- Completed an entrained flow data book.
- Completed multicomponent equilibrium studies, pressure-swing adsorption studies, and modeling for cyclic separation of gases using coal based sorbents.
- Concluded studies on environmental aspects of coal gasification to include waste water management, effluent control systems, and impact of gasification plant environments on worker health.
- Completed studies of novel approaches to usage of micro-organisms for removal of trace amounts of organic contaminants in waste water.
- Completed a study on hybrid gasification reactors that use flexibility and advantages of different designs to maximize coproduct yields for specific industrial applications.
- Concluded studies of integrated gasification systems to provide the data needed to predict optimized configuration for various product yields.
- Completed reactivation of fixed-bed gasification PDU at METC.
- Completed studies on performance of fixed-bed gasifier, hot gas cleanup unit and turbine test stand during integrated operation under dynamic as well as steady state operating conditions.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Advanced research	$ 3,379	$ 968	$ -2,411

The objectives of the Advanced Research (AR) gasification studies include investigations on: (1) new fundamental concepts about coal structures and the physical and chemical mechanisms whereby these structures undergo devolatilization and gasification; (2) mathematical models, based on fundamental principles, which can be used to predict and simulate behavior of gasification and other subsystems under new conditions; (3) laboratory scale experimental and analytical studies of the chemistry and fluid dynamics of ash and slag in various gasification systems; and (4) novel gas separation and gas cleanup processes which have the potential for providing technical and economic advances in gas separation technology.

The following accomplishments are representative of progress expected in FY 1986:

- Advances will be made towards completing a mathematical model that can be used to predict gasification product yields and rates as a function of the chemical structure of coal.
- A novel ion exchange membrane technique will be applied to demonstrate the separation of acid gases from the gasification products.
- A fundamental investigation will be conducted on the use of supported metal complexes as an efficient gas separation method.
- A fundamental investigation of biological approaches to coal conversion will be started.
- New catalyst systems for low temperature water gas shift reactions will be developed for more efficient control of product gas compositions, e.g., low-cost hydrogen production.

The FY 1987 request of $968,000, is a reduction of $2,411,000 from the FY 1986 funding level. This will result in a completion in FY 1986 of all research relating to novel gas separation techniques; and kinetics of coal gasification and devolatilization, including the development of models and experimental verification. In FY 1987, research will continue at a reduced level in the areas of fundamental chemistry and reaction mechanisms associated with mild gasification; and the chemistry of ash and slag from gasifiers.

	FY 1986 Approp.	FY 1987 Request	Net Change
Advanced process development	$ 5,229	$ 1,689	$ -3,540

The FY 1987 request for funds represents a reduction of $3,540,000 from the FY 1986 appropriations. This reduced funding is consistent with a redirection of these activities. This redirected effort now focuses on the support of studies specifically generating data required to establish the feasibility of advanced and novel techniques particularly suited for the application of coal gasification technology in the generation of alternate energy options from coal.

The major objectives of the activities being performed in advanced process development is the generation of a comprehensive technology data base needed for new gasifier concepts. Basic programs involving kinetics and fluid dynamics, thermochemistry and other fundamental concepts including advanced, sophisticated process chemistries, are all part of these high-risk, long-range research projects which have the potential for high payoff upon the successful completion of the experimental work.

In FY 1986, the Advanced Gasification Test Facility was operated and additional data was gathered and evaluated to conclude the development of advanced instrumentation concepts, the development of advanced gas cleanup devices and to define some of the basic concepts of coal gasification in entrained reactors. Innovative techniques (e.g., mild gasification) that have the potential to either increase gasifier yields or dramatically affect the comparative distribution of products produced during the gasification process were further explored and advances were made in gasifier development and application studies, when advanced, new feedstocks (e.g., pulverized, deep cleaned, coal-carbon dioxide mixtures) were used in short residence time, high rate gasifiers. The resulting products were used to develop techniques for the identification of improved processing concepts for increasing their range, and suitability as well as in reducing the cost of utilizing minimally treated pyrolysis products of coal for alternate fuels in advanced energy conversion systems.

Efforts were continued to examine the behavior of fluidized beds when operating under conditions of high temperature and high pressure and to examine the concept of using semi-volatile catalysts within the gasifier itself. These data along with other thermophysical property characteristics of liquid and gaseous mixtures were also used to verify a number of advanced gasifier/gasification process models.

In FY 1987, those efforts performed in FY 1986 to develop innovative techniques with the potential to either increase gasifier yields or dramatically affect the comparative distribution of products generated (i.e., gases, liquids, solids) during the gasification process will be evaluated and the most promising approaches used as a basis for continuing these studies. In addition, studies will be performed to identify and apply new techniques for the application of promising catalyst systems directly to coal as a feedstock or for use within the gasifier itself. The objective of this work will be to realize the potential that exists through this approach to significantly improve system processing flexibility, increase product yields and reduce costs.

Efforts will also continue on studies using coal based sorbents and zeolites in pressure swing adsorption for separation of gases as well as for the development of low cost permeable membranes for hydrogen separation. Studies on the characterization of char during devolatilization will be continued and studies on advanced staged, concurrent rapid rate reactors will be completed. Finally, theoretical studies on coal gasifiers and gasification systems will also be continued.

	FY 1986 Approp.	FY 1987 Request	Net Change
Systems engineering concepts	$27,949	$ 1,373	$-26,576

The reduced level of funding requested for these activities in FY 1987, representing a reduction of $26,576,000 from the FY 1986 appropriation, is the direct result of completing several Proof-of-Concept (POC) and Reliability, Availability and Maintainability (RAM) studies in process development unit (PDU) and demonstration sized gasifiers as well as redirecting some studies away from engineering development efforts.

In general, the work being performed within the category of Systems Engineering Concepts is directed toward the continued development of integrated gasification systems, optimization of concepts for specific applications and achieving the full flexibility of the technology in generating the maximum number of alternate fuel forms from coal. With the completion of the PDU efforts, these studies will focus on the potentially promising concepts that are of a high-risk but which can generate data of direct support to the application of these gasifier systems.

In FY 1986, the evaluation and analysis of operational data that demonstrated the flexibility of the agglomerating ash, fluidized-bed gasification concept was completed. The problems that must be resolved to operate simplified integrated modular gasification systems (gasifiers, hot gas cleanup, particulate removal, etc.) for combined cycle power production were studied. Data generated during these efforts were essential in creating the incentives needed for industry to consider the continued development of such systems. These studies also provided the industrial sector with the data needed to evaluate the use of the ash agglomerating fluidized-bed gasifier for the production of power to convert all types of coal into alternate forms of gas and liquid fuels as well as chemical feedstocks. Work was also completed on the performance testing of the KILnGAS gasification facility. These studies generated significant amounts of data on the Reliability, Availability and Maintainability (RAM) characteristics of the concept of coal gasification. These data were required by the utility and industrial sectors to evaluate the potential and suitability of this concept for use in specific end-use applications. In addition, evaluation and development efforts on a hybrid gasifier concept being considered in the evaluation of new systems capable of optimizing the product yield for specific industry applications were completed. The component and instrumentation part of the systems engineering concepts effort was completed. The successful development of these system enhancement projects have generated data required in the design and construction of more economic and viable coal gasification facilities.

In FY 1987, the cooperative effort with the Gas Research Institute will continue with specific studies and engineering analyses performed on projects of interest to the joint objectives of the combined program. The fixed-bed gasifier at the Morgantown Energy Technology Center will be operated with the experimental emphasis on new methods of obtaining high percentage in situ and/or external sulfur removal to enhance the use of fixed-bed gasifiers using advanced hot gas cleanup concepts. The gasifier will be used to generate a source of "dirty" fuel gas for testing hot particulate removal and chemical and physical gas cleanup devices and the initial steps will be taken to identify and resolve the integration issues associated with the evaluation of a system suitable for the production of new fuels. The fundamental mechanisms leading to a determination of the potential of the zirconia solid state oxygen separator as an alternative to the very expensive cryogenic methods of producing oxygen also will be studied.

	FY 1986 Approp.	FY 1987 Request	Net Change
Environmental and engineering analyses	$ 2,113	$ 1,131	$ -982

The FY 1987 request for funds represents a reduction of $982,000 from the FY 1986 appropriation for this same activity. The reduced level of funding reflects the maturity of the data base for surface coal gasification in the area of environmental concern. Investigative studies on all aspects of coal gasification and its possible impact on the environment resulting from any siting activity mining effort, operation, effluent discharge, product preparation and distribution, etc., have been in progress for many years. These studies have been performed in gasification activities that range from bench scale through the demonstration-sized plant and have generated a very strong and comprehensive environmental data base. A continuing assessment of this data base will be performed to identify any omissions and to focus attention on any areas requiring further study.

Those projects required to generate any additional data, resolve any remaining issues and to develop the technology required to reduce to a minimum any potential environmental impact associated with the implementation of any gasification system on a commercial scale are included as part of this activity.

In FY 1986, studies performed to understand the environmental aspects of each of the processing units as well as the total integrated coal gasification process itself were performed. Enough data were generated to confirm the value of simulation models in making comparative evaluations of promising effluent management techniques and to evaluate "zero discharge" waste water management schemes. Promising results were obtained from studies performed to investigate the application and use of biological micro-organisms in the clean-up of trace organic contaminants in quench and process liquids. The ASPEN process model was demonstrated to be an effective tool for evaluation storage and usage of a wide range of gasification environmental data. Considerable amounts of environmental data were obtained from the operation of the Great Plains Coal Gasification Plant (GPCGP). These data were evaluated and entered into the data base. Work was continued on the compilation, assessment and correlation of the design data produced during DOE's support of the feasibility design and demonstration plant program. The processed data was entered into the gasification technology data base. As part of this effort, a number of gasifier operational codes that had been under development for a number of years by several firms were evaluated, made compatible and entered into the software library available to process modeling activities.

In FY 1987, work will be performed to investigate process modifications in a coordinated effort with downstream cleanup work in fluidized and fixed-bed gasification systems required to reduce the generation of trace hazardous compounds. During the year, the results obtained during the operation of the GPCGP will be used to determine relationships between operational parameters, process efficiency and environmental impact. Earlier trends established at the bench-scale and supported at the PDU/pilot plant level will be compared with full commercial data to identify discrepancies, generate correlations and to identify areas of inadequate information (i.e., data needs). Finally, a study to investigate the fate of trace metals, hydrocarbons and alkalis during the generation and combustion of gaseous fuels from coal will be performed using laser-induced fluorescence instrumentation. These data are essential in developing and utilizing hot gas cleanup systems.

	FY 1986 Approp.	FY 1987 Request	Net Change
Great plains gasification project	$ 2,653	$ 437	$ -2,216

The funding request for the Great Plains Gasification Project (GPGP) in FY 1987 has been reduced by $2,216,000 below the amount of funds appropriated in FY 1986. This reflects a reduction in contract support of DOE's monitoring and management activities.

In FY 1986, the DOE's monitoring and management activities of the project were performed by the Acting Assistant Secretary for Fossil Energy, the Office of Oil, Gas, Shale and Coal Liquids, the Chicago Operations Office, the Grand Forks Project Office and the Morgantown Energy Technology Center.

On August 1, 1985, the Great Plains Gasification Associates partnership notified the government that their consortium intended to abandon the North Dakota facility and default on the $1.5 billion federal loan it received to build the plant. The Department is presently studying sale or lease options for the future operation of this facility. The Department's request is to be utilized in the continued direction and monitoring of the Great Plains project.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

PETROLEUM RESEARCH AND DEVELOPMENT

VOLUME 6

TABLE OF CONTENTS

Advanced Process Technology 101

Enhanced Oil Recovery 107

Oil Shale 115

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
PETROLEUM
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1/] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Advanced process technology (FE)					
Advanced exploratory research:					
Operating expenses	$ 4,380	$ 4,486	$ 4,486	$ 1,576	$ -2,910
Subtotal	4,380	4,486	4,486	1,576	-2,910
Arctic and offshore research:					
Operating expenses	984	1,037	1,037	235	-802
Subtotal	984	1,037	1,037	235	-802
Total					
Operating expenses	5,364	5,523	5,523	1,811	-3,712
Advanced process technology	$ 5,364	$ 5,523	$ 5,523	$ 1,811	$ -3,712
Staffing Total FTE's: Direct ...	0	0	0	0	0
Indirect .	16	15	15	5	-10

[1/] Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Conference	General Reduction	G-M-R Reduction	Total
Advanced process technology (FE)				
Advanced exploratory research:				
Operating expenses	$4,692	$-23	$-183	$4,486
Subtotal				
Arctic and offshore research:				
Operating expenses	1,086	- 7	- 42	1,037
Subtotal, Advanced Process Technology	5,778	-30	-225	5,523
General Reduction:				
Operating Expenses	-30	30	-	-
Total, Advanced Process Technology	$5,748	-	$-225	$5,523
Operating Expenses	5,748	-	-225	5,523

Summary of Changes

FY 1986 Appropriation enacted	$ 5,523
Program increases and decreases:	
Advanced Exploratory Research	
o Complete ongoing extraction technology research and terminate the development of advanced instrumentation	-520
o Complete ongoing fuels testing research and identification of processing needs activity and suspend further work	-883
o Reduce activities in extraction related studies on subsidence and aquifer contamination and suspend further work	-514
o Complete ongoing MEOR technical feasibility analysis studies	-566
o Reduce activities in fundamental petroleum chemistry, thermodynamics, geoscience, and physical properties of petroleum and synthetic crudes	-427
Subtotal	-2,910
Arctic and Offshore Research	
o Reduce activities in Arctic energy data base development and maintenance	-604
o Complete ongoing fundamental ice research	-198
Subtotal	-802
FY 1987 budget request	$ 1,811

Advanced process technology:

Goals/Objectives:

The Advanced Process Technology (APT) program serves the dual purpose of exploring new concepts with the potential to achieve quantum increases in efficiency and significant cost reduction of recovery techniques for oil, gas, and oil shale and to conduct fundamental research that is relevant to oil, gas, and oil shale recovery, where the experimental procedure, method being developed, or item of concern is more important than the resource being investigated.

There are two goals within the APT Program. These are:

- o To pursue the fundamental research relevant to oil, gas, and shale recovery, i.e., development of the tools and techniques to measure and predict important properties and phenomena, and to obtain the fundamental data critical to these recovery processes.
- o To provide the proper environment to conduct research and to pursue application of new frontiers of science and/or as yet unexplored new concepts to achieve quantum increases in recovery efficiency for oil, gas, and shale resources.

During the APT program planning process, an evaluation of the needs of oil, gas, and shale technologies is conducted. Based on this evaluation a prioritized list of research needs is compiled according to the potential crosscut benefits to oil, gas and shale programs.

As to the second goal of the APT program, the intent is to evaluate new methods of resource extraction that offer the potential for very significant increases in energy efficiency, more favorable economics, or environmental benefits. Emphasis is placed on soliciting ideas from outside the Department of Energy in order to assure that the program takes advantage of the best ideas that the nation and international sources have to offer. After the feasibility of the idea has been determined it can then be transferred to the relevant technology program for development or if warranted the research may be terminated. An example of this transfer process is the microbial enhanced oil recovery (MEOR) thrust prior to FY 1987. It was under the auspices of the APT program where it was determined that the method appears feasible and warrants an increased research effort. Thus in FY 1987 MEOR is being transferred to the Enhanced Oil Recovery program for implementation.

FY 1986 Accomplishments:

FY 1986 accomplishments include:

- Complete technical feasibility analyses conducted by four universities and define a program of research addressing research needs requisite to applying microbial EOR in a production mode.
- Continue fundamental petroleum chemistry research focusing on physical and chemical characterization studies of heavy oil; thermodynamic measurements; shale oil and tar sands bitumen studies and fuel storage and handling.
- Complete ongoing extraction technology research focusing on reservoir characteristics and advanced instrumentation development.
- Complete ongoing fuels testing research, correlation of fuels composition and processing needs, and predictive models relating process to composition.
- Continue ongoing extraction related studies which will focus on the mitigation of aquifer damage and subsidence problems.
- Continue the update and maintenance of the Arctic/offshore oil and gas research data base.
- Complete ongoing fundamental ice research to characterize size, composition, degree of consolidation, temperature and salinity profiles.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Advanced exploratory research	$ 4,486	$ 1,576	$ -2,910

The reduction of $2,910,000 from the FY 1986 funding level reflects a focusing of research at the National Institute for Petroleum and Energy Research and discontinuation of university and national laboratory efforts in geoscience, chemical EOR, and reservoir diagnostics. All efforts conducted in FY 1986, with the exception of fundamental petroleum, geoscience, acquifer contamination, and chemistry research were completed. More specifically, in FY 1986, activities in microbial enhanced oil recovery were brought to a close in regard to investigating the technical feasiblity of the concept. A program was developed to define research needs that must be addressed prior to application of microbial enhanced oil recovery in a production mode. The National Institute for Petroleum and Energy Research (NIPER) continued a program of research to establish the chemical, physical and thermodynamic properties of heavy oil and syncrude feedstocks essential to defining problem compounds and properties requisite to introducing them into the present infrastructure; and developing analytical models correlating alternate crude/fuel composition to processing and utilization (combustion properties). Also a planned 3-year university/industry research effort in support of geosciences and chemical flooding related to enhanced oil recovery (initiated under a FY 1985 PRDA) was brought to completion in FY 1986 as were national laboratory efforts to develop diagnostics to measure key reservoir parameters in-situ.

In FY 1987, research will continue at NIPER in fundamental chemistry, physics and thermodynamics on heavy petroleum, tar sands bitumen, and oil shale feedstocks in an attempt to focus efforts and benefit from the government/industry interface available through this institution. Included in this research will be the development of more practical analytical tools and techniques for the analysis of the heavier ends. Under the joint U.S./Venezuela agreement, work will continue on the characterization of heavy crude oil. This effort was redirected during FY 1986 to emphasize developing the improved means of characterization rather than continuing to determine the properties of specific crudes, such as the Venezuelan Cerro Negro heavy oil. Under the joint U.S./Israel agreement, work will continue on the chemical aspects of acquifer contamination.

	FY 1986 Approp.	FY 1987 Request	Net Change
Arctic and offshore research	$ 1,037	$ 235	$ -802

In FY 1986, efforts continued in establishing consolidated, coordinated, central arctic oil and gas research information and data base systems as recommended in a National Petroleum Council study on arctic development. This study identified the need for a coordinated energy related information/technology data system where the myriad of industry, academia and government agencies could access and input information. Research was also conducted to establish the characteristics of the ice islands and ice ridges which pose a hazard to offshore structures.

In FY 1987, an annotated bibliography relevant to energy development will be prepared; the key element of the Arctic and Offshore Research Information System will reflect the state-of-the-technology as of FY 1987. All other planned technology base activities will be suspended or be the subject of a cooperative R&D venture pool project, e.g., cooperative work with the State of Alaska and Arctic Ocean rim countries.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
PETROLEUM
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1/] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Enhanced oil recovery (FE)					
Heavy oil:					
Operating expenses	$ 2,557	$ 2,756	$ 2,756	$ 608	$ -2,148
Subtotal	2,557	2,756	2,756	608	-2,148
Light oil:					
Operating expenses	7,965	7,381	7,381	3,876	-3,505
Subtotal	7,965	7,381	7,381	3,876	-3,505
Tar sands:					
Operating expenses	1,180	1,317	1,317	...	-1,317
Subtotal	1,180	1,317	1,317	...	-1,317
Total					
Operating expenses	11,702	11,454	11,454	4,484	-6,970
Enhanced oil recovery	$11,702	$11,454	$11,454	$ 4,484	$ -6,970
Staffing Total FTE's: Direct ...	6	6	6	3	-3
Indirect .	17	17	17	10	-7

[1/] Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Conference	General Reduction	G-R-H Reduction	Total
Enhanced oil recovery (FE)				
Heavy Oil:				
Operating expenses...........	$ 2,886	$-17	$-113	$2,756
Light Oil:				
Operating expenses...........	7,721	-38	-302	7,381
Tar sands:				
Operating expenses...........	1,379	- 8	- 54	1,317
Subtotal, Enhanced Oil Recovery (FE)........	11,986	-63	-469	11,454
General Reduction:				
Operating Expenses............	-63	63	-	-
Total, Enhanced Oil Recovery (FE)	$11,923	-	$-469	$11,454
Operating Expenses.......	11,923	-	-469	11,454

Summary of Changes

FY 1986 Appropriation enacted	$11,454
Program increases and decreases:	
Heavy Oil	
o Complete national laboratory and university studies on basic oil mobilization and EOR process mechanisms and focus research at NIPER	-2,148
Light Oil	
o Complete university research studies on chemical flooding and focus efforts at NIPER	-3,505
Tar Sands	
o Discontinue laboratory/bench scale efforts to investigate thermal recovery kinetics and mechanisms and to identify promising recovery concepts.	-1,317
FY 1987 budget request	$ 4,484

Enhanced oil recovery:

Goals/Objectives:

The goal of the Enhanced Oil Recovery (EOR) program is to conduct generic technology base R&D activities; develop fundamental knowledge that can lead to improved and new process concepts; and to assist industry in obtaining a better understanding of the mechanisms and behavior of advanced and novel EOR processes for the recovery of presently unrecoverable light oil, heavy oil and tar sand resources.

Enhanced Oil Recovery (EOR), often used synonomously with Tertiary Oil Recovery is the term used for recovery techniques applied after conventional means are employed or where conventional means are not effective. Conventional methods include primary recovery where natural, in situ drive mechanisms are utilized to produce the oil, or secondary water flood techniques are used to displace additional oil. Enhanced recovery or tertiary oil recovery methods usually represent the third attempt to recover the otherwise unrecoverable oil, except for heavy oil and tar sand reservoirs where EOR technologies may have to be applied from the very beginning.

One of the most comprehensive reports on the future of EOR in the United States was recently completed by the National Petroleum Council (NPC) at the request of the Secretary. The study points out that only 27% of all the oil discovered in the United States was produced (130 billion barrels) and that only 6% remains to be produced with conventional technologies (28 billion barrels). This leaves 323 billion barrels or 67% of the otherwise unrecoverable oil as the target for EOR. This oil remains out there, not waiting to be discovered but in places we know, in fields that are opened, but trapped in geology and by forces that are still beyond the grasp of today's production technology.

The NPC study recommends a number of research areas in EOR and states in the transmittal letter to the Secretary that "only through continued process research and field testing with both industry and government support, can the large volume of hydrocarbons discussed in the report be produced." Using today's EOR knowhow, the NPC report concludes that 14.5 billion barrels--the equivalent of about half our current recoverable reserves--could be added to the domestic crude oil supply. Further, NPC concludes that advances in technology could double that amount. This still leaves more than 300 billion barrels of oil in the ground.

Because of the present world energy situation and restructuring of the oil industry, exploration for new reserves has dropped off, particularly in the domestic arena. But even in the recent past when exploration was at a peak, reserves were being added at a rate far below that previously experienced, and the average size of reservoirs discovered was found to be declining rapidly. Overall, domestic production has been on the decline for 15 years with some states experiencing serious economic consequences, because of drastic reductions in production. This only emphasizes the importance of relying on existing, but currently unrecoverable, oil resources and new technologies to recover that oil. Also, from a purely strategic point of view, EOR can help fill the oil supply shortfall after the strategic reserve runs out and before synthetic fuels make measurable impact on oil supply.

Fundamental research envisioned under the EOR program expects to look at the problem as a whole and will attempt to provide solutions to discrete research requirements which can then become the necessary building blocks for innovative process development by the industry. The focus of the EOR program is thus based on obtaining a clearer understanding of the scientific processes through long-range technology base research.

The U.S. does have considerable heavy oil (approximately 100 billion barrels) and tar sand resources (54 billion barrels) but our neighbors to the north and south have orders of magnitude larger in-place resources. Canada has an estimated 1.2 trillion barrels contained in their tar sands and Venezuela has 1 to 4 trillion barrels in their heavy oil deposits. Mexico is still determining the magnitude of their petroleum deposits (both heavy and light oil) but they are known to be vast. It is therefore important from a strategic standpoint to develop efficient, effective and economic recovery technologies for these resources. The fact that Canada, Venezuela and Mexico have mutual interests in recovery research affords us the opportunity to leverage our resources through cooperative research efforts. We do in fact have active and mutually beneficial agreements in place with these countries and are task sharing research on defined critical needs.

The specific objectives of the EOR program are to:

- Conduct fundamental research into the behavior of light oil EOR processes such as micellar-polymer and carbon dioxide flooding with mobility control for significantly higher recovery efficiency.
- Develop a better understanding of heavy oil EOR processes such as steam flooding, and the complex chemical/physical in situ mechanisms by which oil is mobilized and recovered efficiently.
- Evaluate and develop new concepts for in situ recovery of bitumen from U.S. tar sands deposits.
- Provide technical support and conduct environmental research pertaining to hazards in use of chemicals in light oil recovery and to combustion products from thermal recovery of heavy oils.
- Continue technology transfer activities with government agencies and industry.
- Evaluate environmental impediments or concerns which could constrain realization of EOR goals.

FY 1986 Accomplishments:

- Continued joint research with Venezuela and Mexico on heavy oil characterization, thermal recovery evaluation, subsidence prediction and reservoir modeling.
- Phased out university investigations into the kinetics of oxygen-enriched in situ combustion and National Laboratory research into the generation and stability of foam in reservoirs.
- Continued fundamental studies of surfactant behavior in EOR concepts and applications.
- Continued studies of geologic heterogeneities and other characteristics on EOR process shortcomings.
- Conducted basic studies of rock-fluid interaction phenomena and behavior.
- Continued studies of CO_2 displacement mechanisms and viscous channeling and mobility control concepts.

- o Continued joint test program with Canada for assessing advanced concepts of remote tracking of thermal fronts for control of in situ combustion process of tar sands recovery, and cooperative development of methodology for tar sand resource and bitumen analysis.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Heavy oil	$ 2,756	$ 608	$ -2,148

FY 1987 funding for this subprogram is $608,000, a reduction of $2,148,000 from the FY 1986 funding level. This reduction will result in the following:

- o Completion of research on in situ combustion reaction kinetics and variables in alkaline flooding in EOR.
- o Completion of the remaining joint research with Venezuela and Mexico on novel heavy oil recovery processes.

Heavy oil (10^0-20^0 API gravity) makes up an estimated one-third of the U.S. petroleum resource, or about 100 billion barrels. This heavy oil is very viscous, somewhat like molasses, and hence moves very slowly in the reservoir. For this reason, very little heavy oil is produced during primary recovery, and enhanced recovery techniques are required for further production. The most common EOR methods are targeted towards the reduction of viscosity of the heavy oil in place so that it can flow easily through the reservoir. Current technologies consist of applying heat to the reservoir through injection of steam or by in-situ combustion.

About 450,000 barrels of heavy oil is produced daily (mostly in California) using thermal recovery methods. Despite this apparent success, experts agree that the potential for heavy oil recovery is much larger (NPC Study on EOR, 1984). The main problem in thermal recovery is that of efficient displacement of the oil. Because of its light weight and very low viscosity, steam tends to bypass a large portion of the reservoir and breaks through to the producing wells. Research is required on modifying the flow behavior of steam which can result in greatly improved displacement efficiency. Materials are needed which can withstand the high temperature, pressure, and the dynamics of flow through the reservoir rocks. Certain chemical additives are proving to be useful in yet to be fully understood ways in improving steam displacement efficiency in selected reservoirs. In-situ combustion processes are more complex and still require a great deal of basic research to obtain a complete understanding of its subsurface behavior.

Certain heavy oils have acidic components that can react with alkaline chemicals to form surfactants in place. Alkaline chemicals such as sodium hydroxide can thus be used to initiate an in-situ surfactant flood. Further understanding of the reactions is necessary before this method can be applied with reasonable predictability.

The EOR heavy oil research program is mainly focused towards significantly improving the displacement efficiency of thermal recovery processes. To achieve this, research in modification of steam flow behavior, mobility control, chemical additives and kinetics of in-situ combustion will be required. Basic research efforts in use of alkaline chemicals for surfactant flooding will also be needed. As in the case of light oils, methods beyond those presently conceived will be required to recover much of the heavy oil. Thus an essential element of the Heavy Oil subprogram will be to explore new concepts for producing this remaining oil.

To address the vast amount of residual oil remaining even after applying the presently conceived advanced case technologies requires new approaches. Microbial EOR (MEOR) is one such approach, i.e., the use of micro-organisms to lower viscosity, develop miscible gases, etc., for displacement of the residual oil. Preliminary concept feasibility analyses have been done under the APT program. The potential has been established and the effort transferred to the EOR program to begin the research toward developing MEOR systems concepts. Also, to address the more challenging complex reservoir conditions associated with the bulk of the oil remaining, alternate strategies to affect more control over the reservoir will be required than are possible with presently conceived systems.

As mentioned previously, the worldwide resources of heavy oil are enormous, especially in neighboring countries such as Canada, Mexico and Venezuela. Active and mutually beneficial cooperative research conducted in FY 1986 and previous years will be continued in FY 1987 with these countries in critical areas if such research competes successfully for funds under the Oil, Gas and Shale Cooperative R&D Venture Pool.

In FY 1986, heavy oil research included theoretical studies of multiphase fluid flow using steam with foam for mobility control, physical and computer simulation of steam with additives, kinetics of oxygen-enriched in-situ combustion, and continuation of research with Venezuela and Mexico.

In FY 1987, heavy oil research will be focused at the National Institute for Petroleum and Energy Research (NIPER). Taking advantage of the government/industry interface afforded through this institution, work will include the following:

- Identification of additives for improving thermal recovery methods and investigation of the mechanisms to enable design of improved techniques.
- Use of physical models and mathematical simulation to evaluate steam flooding and in-situ combustion in terms of kinetics, rheology, and displacement process.

	FY 1986 Approp.	FY 1987 Request	Net Change
Light oil	$ 7,381	$ 3,876	$ -3,505

FY 1987 funding for this subprogram is $3,876,000, a reduction of $3,505,000 from the FY 1986 funding level. The effect of this reduction will be the phasing out of basic research and pursuit of novel extraction concepts studies performed at several universities and National Laboratories.

Light oil (over 20^0 API) constitutes the largest percentage of the domestic crude oil resource--with approximately 230 billion barrels remaining in the ground as a target for EOR. There exist two core technologies for the enhanced production from light oil reservoirs: chemical flooding and miscible gas flooding.

Chemical flooding techniques involve the injection of surfactants in the target formation to reduce surface tension and ionic bonding between the residual oil and connate water and residual oil and sedimentary rock surfaces. A polymer slug is injected behind the surfactant to drive the fluid through the formation. In the laboratory, high recovery efficiencies are realized. However, in the field the results have for the most part been disappointing and unpredictable. The mechanisms that appear to cause the erratic and inefficient performance in the field relate to chemical and physical breakdown of the surfactant and polymers under formation pressures, temperature, high salinity and complex checmical composition; to adsorption and absorption of the surfactants; and to non-uniform flow behavior. Development of predictable, efficient and economical chemical flooding EOR technologies require a thorough understanding of the rock/fluid interactions and identification of surfactants and polymers compatible with the range of reservoir conditions encountered. Industry and DOE, under the EOR program, have conducted research in the past to address the problems associated with this technology. Recent and continuing DOE efforts will be focusing on the long-term, more fundamental research to build an analytical base as recommended by the NPC study.

Miscible gas (CO_2) recovery involves the injection of CO_2 into the formation under pressure. The CO_2 dissolves into the residual oil in the reservoir and works as a solvent to reduce viscosity and enhance flow characteristics. It is quite effective where it makes contact with the residual oil. Unfortunately, CO_2 moves rapidly through the formation because of its low viscosity relative to the formation fluids. The result is low sweep efficiency with the gas following the path of least resistance. Research by industry and DOE has therefore focused on developing mobility control methods, e.g., the addition of chemicals (such as foaming agents) to increase viscosity and enhance sweep efficiency. As in the case of chemical flooding, the DOE work is fundamental to provide an analytical base for industry efforts.

In FY 1986, light oil research activities included fundamental studies of surfactant properties and geologic parameters as they affect chemical flooding, continuation of research in phase behavior and viscous fingering phenomena in miscible gas flooding and comprehensive post-project analysis and updating and documenting of six process models.

The FY 1987 budget will allow continuation of NIPER's fundamental research into the recovery mechanisms and physical and chemical phenomena which hold the residual oil in the reservoir and prevent displacement. Work will include: investigations of polymer rheology and stability at elevated temperatures; effects of pore size on injectivity; absorption behavior of surfactants; the relationship between electrical properties and stability of colloidal surfactant systems; and the fundamental chemistry of copartitioning alcohol/surfactant systems. NIPER will also continue its studies of nitrogen and CO_2 gas flooding concepts, both miscible and immiscible, with emphasis on displacement mechanisms, mobility control, and the development of improved screening criteria. Microbial EOR, previously part of the APT program will now be a part of the EOR program and be addressed under the NIPER cooperative agreement. Similarly, METC will continue laboratory core testing of CO_2-surfactant-water foam systems of mobility control and basic CO_2 process technique assessments using its innovative miscible black oil model. Post-test analysis and process evaluation will be completed for the recently completed, cost-shared field test of micellar polymer EOR.

	FY 1986 Approp.	FY 1987 Request	Net Change
Tar sands	$ 1,317	$ ...	$ -1,317

No funds were requested in FY 1987 for this subprogram. All activities, except previously funded, task shared, U.S./Canadian basic tar sand research activities, will be completed in FY 1986.

Tar sand bitumen (less than 10° API) is a semi-solid, bituminous substance similar to asphalt or resin. It is totally immobile in the reservoir and therefore must either be mined and processed at the surface as in Canada, or heated in situ as in heavy oil recovery. Domestic tar sand resources are estimated at 54 billion barrels, however, currently there is no commercial production from these deposits.

Canada, however, produces over 200,000 BPD of bitumen and has an ongoing research program in tar sands. Although its commercial operations are largely surface processing, research emphasis is swinging toward in situ recovery in preparation for the day when its easily mined deposits run out. The surface processes developed in Canada serve as a starting point for design of technologies compatible with the estimated 15-20% of our tar sands amenable to mining and surface processing.

In FY 1986, DOE tar sand research focused on the development of concepts of recovery principally at the Western Research Institute (WRI) under an initial cooperative agreement expiring at the close of FY 1986, using small scale tube reactors and unique block test apparatus (allowing tests on 2x2x6 foot consolidated tar sand samples) to investigate in situ thermal recovery scenarios and the effect on product yield and quality and waste stream pollutant species and concentrations. A limited effort conducted at the University of Utah to explore surface process technologies compatible with major U.S. tar sand deposits and to examine techniques for efficient separation of bitumen from the process fluids was similarly phased out. In addition, through the Office of the Canadian Federal Government and the Provinces of Alberta and Saskatchewan, Canada has continued to extend and fund cooperative research endeavors with DOE in tar sand research in the development of steam with additives technology and in situ mechanisms to enhance sweep efficiency; and in development and field testing of a cost effective remote thermal front tracking capability.

In FY 1987, basic tar sand research activities will be limited to previously funded, task shared, U.S./Canadian activities. These research activities could be supplemented by funds under the oil, gas and shale cooperative R&D venture pool.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
PETROLEUM
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Oil shale (FE)					
Oil shale technology base:					
Operating expenses	$ 8,728	$ 8,447	$ 8,447	$ 3,078	$ -5,369
Subtotal	8,728	8,447	8,447	3,078	-5,369
Environmental mitigation:					
Operating expenses	5,900	3,689	3,689	517	-3,172
Subtotal	5,900	3,689	3,689	517	-3,172
Total					
Operating expenses	14,628	12,136	12,136	3,595	-8,541
Oil shale	$14,628	$12,136	$12,136	$ 3,595	$ -8,541
Staffing Total FTE's: Direct ...	10	13	13	12	-1
Indirect .	7	8	8	8	0

[1] Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Conference	General Reduction	G-R-H Reduction	Total
Oil Shale (FE)				
Oil shale technology base:				
Operating expenses.........	$ 8,839	$-47	$-345	$8,447
Environmental Mitigation				
Operating expenses.........	3,860	-20	-151	3,689
Subtotal, Oil Shale (FE)	12,699	-67	-496	12,136
General Reduction:				
Operating Expenses	-67	67	-	
Total, Oil Shale (FE)	$12,632	-	$-496	$12,136
Operating Expenses.........	12,632	-	-496	12,136

situ retort technologies have been proven for certain site specific situations, e.g., the Geokinetics process where shallow lying thin deposits on the basin rims can be sufficiently fragmented to affect reasonable recovery. Modified in situ technology such as that proposed by Occidental poses economic questions and a high degree of risk because of the fairly extensive mining associated with it and an inability to predict, from one geologic setting to another, whether an explosive design will provide the necessary fracturing. Also, there are environmental questions associated with eventual abandonment. There is a need to explore more efficient, economic recovery systems and systems that can be applied effectively to a larger percentage of the resource. Excluding the Occidental Vertical Modified Insitu approach, the remainder of the approaches are at best marginally economic when applied to the easily accessed high grade zones representing only 5 to 10% of the total Western resources.

Aside from the conversion process, there are significant cost and environmental considerations relative to air, water and solid wastes generated from oil shale plants. As to the air emissions, best available control technology can be applied to meet standards for regulated pollutants for a single plant. But required environmental considerations would soon limit industry development due to total allowed emissions. Clean-up of process water and codisposal with spent oil shale pose significant potential impact to the regions hydrology and ecology. Evaporative emissions from the spent shale, spent shale pile structural and chemical stability, and transport of toxic substances to vegetation must be evaluated and mitigation methods developed before an oil shale industry will achieve environmental acceptability.

The Oil Shale Program was restructured in FY 1984. Evolving from that restructuring was a systems approach to develop essential process and environmental data for both Eastern and Western shales. Eastern and Western shales are to be selected on the basis of established criteria, subjected to an indepth characterization of organic and inorganic constituents. These reference shales are then to be processed in laboratory retorts under a prescribed set of conditions and the product and waste streams are to be characterized to determine the fate of the oil shale constituents as a function of process condition. Other aspects of the restructured program are to focus on environmental problems discussed above; and to explore promising new concepts for enhanced process economics, recovery efficiency, and reduced environmental impact.

As a result of new administration policy, the Oil Shale program will focus on the basic research using reference shales to systematically study the chemistry, kinetics, and emissions related to eastern and western oil shale processing. High capacity, continuous throughput solids recycle process conditions will be emphasized for the near term. Present contracts with industry to explore new concepts will be completed or terminated in FY 1986. In FY 1987, such oil shale projects could be eligible to compete for Fossil Energy joint venture pool funds.

FY 1986 Accomplishments:

FY 1986 Accomplishments include:

- Completion of reports by Western Research Institute on incorporation of gas pressure drop, individual oil boiling fractions and liquid water behavior into the one-dimensional retorting model; on radiofrequency heating tests to measure oil yields at different heating rates; and on ambient emissions of spent shales.
- Completion of a final report on preliminary design of a 500 Tpd pilot plant utilizing a roller grate retort and Indiana shale.
- Completion by Los Alamos National Laboratory of reports on oil shale fragmentation tests conducted at the Anvil Points and Colony mines; and on a study to develop prioritized issues relative to commercial facility siting.
- Completion of report of phase I and II of a project to determine the feasibility of in situ retorting of Indiana oil shale.
- Completion of report by Lawrence Livermore National Laboratory of studies of reduction of NO_x emissions, and on operation of a solids recycle system with fluidized bed pyrolyzer and gravity flow mixer.

Summary of Changes

FY 1986 Appropriation enacted	$12,136
Program increases and decreases:	
Oil Shale Technology Base	
o Reduced specific eastern oil shale research	-472
o Discontinue further development of ASPEN codes specific to oil shale systems analysis	-122
o Reduce laboratory studies of reference shale retorting and modeling for solids recycle systems	-991
o Discontinue in situ process and fragmentation model development	-2,834
o Defer further activity in oil shale extraction research	-956
o Continue development of the data base	+6
Subtotal	-5,369
Environmental Mitigation	
o Discontinue studies to develop siting methodology	-376
o Reduce environmental data base activities	-94
o Discontinue research on nitrogen emissions and sulfur capture in solids-recycle retort systems	-192
o Reduce real-time emissions measurements consistent with reduced reference shale retorting studies in moving beds and in in situ simulating laboratory retorts, and defer further studies of critical questions associated with spent shale disposal	-2,510
Subtotal	-3,172
FY 1987 budget request	$ 3,595

Oil shale:

Goals/Objectives:

The goal of the Oil Shale R&D program is to provide a sound technologic basis for reduction of economic and environmental constraints to industrial development of the U.S. oil shale resources; and to increase the amount of resource that may be used economically.

Oil Shale represents a vast hydrocarbon resource in the U.S. that can be converted to a broad spectrum of products from raw kerogen (the heavy complex hydrocarbon contained in the mineral matrix) which can be combusted or used as a petrochemical feedstock, or converted to diesel and jet fuel. An estimated 1.8 trillion barrels of oil equivalent reside in place in the Green River Formation of Colorado, Utah and Wyoming; and an equal volume is believed to exist in the more far ranging (and less explored) Devonian and Mississippian oil shales of the east and midwest. The Western, Green River Formation deposits, are in fact marlstones formed from fresh water lakes. They have a high carbonate composition, and high hydrogen to carbon ratio in the organics creating chain structures called aliphatics. The Eastern, Devonian and Mississippian deposits are true marine shales. They have a high Illite content, and relatively low hydrogen to carbon ratio in the organics creating ring structures called aromatics. Alphatics are more easily converted to liquids with heat than are aromatics; therefore, eastern shales with the same organic content as a western shale will produce less liquid when subjected to a simple heating process. However, a drawback to retorting of Western shales is the carbonate which absorbs heat upon decomposition.

A suite of oil shale surface retort technologies exist today for processing high volumes of Western shale at what can best be described as marginal economics (45-55 $/BBL). In

- Completion of a report by the University of Alabama Mineral Resources Institute on assessment of U.S. oil shales amenable to beneficiation followed by hydroretorting. Three of the most promising shales are to be selected for further testing.
- A report on the first year effort to expand the technology base for moving-bed hydroretorting of eastern shales including fines utilization is expected to be prepared by Hycrude, Inc.
- Initiate and complete studies to determine research needs and recommended tasks/activities for implementation of an oil shale extraction research program through the Idaho Operations Office.
- Initiate a cooperative agreement with the Western Research Institute (WRI).

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Oil shale technology base	$ 8,447	$ 3,078	$ -5,369

The FY 1987 funding request for this subprogram is $3,078,000, a reduction of $5,369,000 from the FY 1986 funding level. This requires consolidation of the previous LLNL work on solids recycle chemistry and modeling into METC's research as subsequently described, and termination of all work at LLNL, SNL, and LANL.

The goal of the Oil Shale Technology Base program is to conduct basic research that provides a sound scientific basis for reduction of economic constraints to industrial development of the U.S. oil shale resources and to increase the amount of resource that may be used economically.

In FY 1986, efforts conducted at WRI emphasized basic research to improve understanding of the criteria for successful in situ processing of oil shale; detailed characterization studies of reference eastern and western shales; and basic research on new process concepts. Other WRI activities are described under Environmental Mitigation. Also in FY 1986, a contract study of a roller grate process concept applied to Indiana shale was completed, and a contract study of an in situ process concept applied to Indiana shale was continued and scheduled for completion in FY 1987. A university contract study of eastern shale beneficiation and hydrogen retorting was continued in FY 1986 and will be phased out in FY 1987 utilizing prior year funding. A contract study involving further applied research on eastern shale hydrogen retorting will be completed in FY 1987. Studies will be implemented and completed in FY 1986 to identify research needs in oil shale extraction and to propose a program for implementation through DOE's Idaho Operations Office as directed by the Congress.

In FY 1986, basic research was ongoing at Lawrence Livermore National Laboratory (LLNL) on solids recycle retorting and modeling; at Sandia National Laboratory (SNL) and Los Alamos National Laboratory (LANL) on in situ process and fragmentation modeling; and at Morgantown Energy Technology Center (METC) on process chemistry and kinetics, systems analysis, and development of computerized data bases.

In FY 1986, a contract awarded to Terra Tek, Inc., in FY 1985 to obtain reference shales and maintain a sample bank in support of the in house research program was continued, and will be continuing in FY 1987.

In FY 1987, the Morgantown Energy Technology Center will carry out an in-house program of research in the following areas:

- In depth characterization of oil shales to undergo process studies to provide a reference from which to interpret process mechanisms; and characterization of process products.
- Rapid pyrolysis studies on both eastern and western shales to define kinetics and mechanisms of oil shale decomposition phenomena and how process conditions affect product yield and quality.

- o Modeling of process phenomena to provide a framework to deal with process variables; to build an understanding of the interrelationship between process parameters; and to serve as a tool in designing experiments to fill data gaps.
- o Experimentation to address liquid-phase organic formation from organic vapors.
- o Quantification of the breakdown experienced by spent shale in solids recycle retort systems and the effect on heat transfer capability.
- o Development of a generic solids recycle process model incorporating retort and combustor phases.

	FY 1986 Approp.	FY 1987 Request	Net Change
Environmental mitigation	$ 3,689	$ 517	$ -3,172

The goal of the Oil Shale Environmental Mitigation program is to conduct basic research that provides a sound scientific basis for reduction of environmental constraints to industrial development of U.S. oil shale resources and to increase the amount of resource that may be used economically.

The FY 1987 funding request for this subprogram is $517,000, a decrease of $3,172,000. This reduction is a result of completing siting methodology studies as well as research on nitrogen emissions and the capture of sulfur by oil shale compounds under varying process conditions. The largest reduction however, is associated with efforts identifying and quantifying major and trace element emissions in gases, liquids and solids from reference shales.

In FY 1986, WRI completed basic research on solid waste and co-disposal and characterization of air and water emissions. Sulfur and nitrogen chemistry work that was being performed at Lawrence Livermore Laboratory during FY 1986 will be integrated with ongoing research at the Morgantown Energy Technology Center (METC). Los Alamos National Laboratory completed a study in FY 1986 of research needs pertinent to developing a methodology for analyzing impacts of oil shale facility siting. No further work in siting methodology will be conducted in FY 1987.

In FY 1987, METC will carry out an in-house program of research in the following areas:

- o Developing a fundamental understanding of the role of solids in solids recycle retorts in regard to removal of sulfur and nitrogen from vapor phase organic compounds during oil shale retorting.
- o Determining the extent of solids carryover into the product stream from solids recycle retorts and exploring mitigation strategies.
- o Modeling the sulfur and ammonia recovery process sections of a generic oil shale plant to aid in quantifying the impact of applying various retort process options.
- o Applying systems analysis methodologies to help define and prioritize research needs.

In FY 1987, under a annex to an umbrella agreement with Israel, research concerned with sulfur compound identification in oil shale waste streams is expected to continue as is health and safety related research support under an Interagency Agreement with the Bureau of Mines.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
GAS
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 1/ Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Unconventional gas recovery (FE)					
Eastern gas shales:					
Operating expenses	$ 2,852	$ 938	$ 938	$ 355	$ -583
Subtotal	2,852	938	938	355	-583
Western tight gas sands:					
Operating expenses	5,028	5,393	5,393	3,582	-1,811
Subtotal	5,028	5,393	5,393	3,582	-1,811
Environmental and advanced research:					
Operating expenses	2,262	2,172	2,172	1,315	-857
Subtotal	2,262	2,172	2,172	1,315	-857
Total					
Operating expenses	10,142	8,503	8,503	5,252	-3,251
Unconventional gas recovery	$10,142	$ 8,503	$ 8,503	$ 5,252	$ -3,251
Staffing Total FTE's: Direct ...	10	11	11	10	-1
Indirect .	12	11	11	10	-1

1/ Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy
FY 1987 Congressional Budget Request
Adjustments to FY 1986 Appropriations

	FY 1986 Conference	General Reduction	G-R-H Reduction	Total
Unconventional gas recovery (FE)				
Eastern gas shales:				
Operating expenses	$ 981	$- 5	$- 39	$ 938
Western tight gas sands:				
Operating expenses	5,642	29	-220	5,393
Environmental and advanced research				
Operating expenses	2,273	-12	- 89	2,172
Subtotal, Unconventional Gas Recovery (FE)	$8,396	$-46	$-347	$8,503
General Reduction:				
Operating Expenses	-46	46	-	-
Total, Unconventional Gas Recovery (FE)	$8,850	-	$-347	$8,503
Operating Expenses	8,850	-	-347	8,503

Summary of Changes

FY 1986 Appropriation enacted	$ 8,503
Program increases and decreases:	
Eastern Gas Shales	
o Cancel scheduled stimulation of horizontal well drilled in FY 1986; also termination of planned stimulation model validation efforts	-583
Western Tight Gas Sands	
o Reduce level of effort in Multiwell Experiment and supporting research	-1,016
o Discontinue geologic/engineering studies of the Uinta and Greater Green River Basins	-253
o Discontinue supporting research for the Western Gas Sands program	-542
Subtotal	-1,811
Environmental and Advanced Research	
o Discontinue all university laboratory/field property determiniation efforts for gas hydrates and terminate all contract geologic characterization efforts	-612
o Discontinue detection/differentiation system development for deep source gas	-245
Subtotal	-857
FY 1987 budget request	$ 5,252

Unconventional gas recovery:

Goals/Objectives:

The unconventional gas resource in place is large, on the order of thousands of trillion cubic feet (TCF) and many times the size of our domestic reserves. The primary issue surrounding unconventional gas is not its size, but how much of the resource can be recovered. However, recovery of these resources represents a technological challenge. If successfully met, this additional gas combined with conventionally recovered gas would represent a secure domestic supply that could meet the nation's needs well into the next century both for existing markets and in an expanded market displacing imported oil.

The unconventional gas resources addressed under the UGR program are the tight lenticular sand formations of the west, fractured shales of the east, and the lesser known novel gas resources of gas hydrates and deep sources. Each of these resources is large, or estimated to be large, but is lacking a sufficient knowledge base to warrant significant industry investment. They are all geologically complex and require advances in extraction technology if substantial volumes are to become technically and economically producible.

The specific objectives of the Unconventional Gas Recovery program are to:

- o Reduce the uncertainty surrounding the potential magnitude of reserves of the unconventional gas resources and the conditions under which they will be produced.
- o Develop and improve extraction technologies to the point of technical readiness for private sector development.
- o Transfer all technical and economic data to industry.

FY 1986 Accomplishments.

Eastern Gas Shales
- Completed installation of a directionally drilled horizontal well to test for increased gas recovery efficiency.
- Established hydraulic fracturing design criteria for natural fractured reservoirs using physical-scaled models.
- Completed testing and analyses from a second offset well test facility.

Western Tight Gas Sands
- Completed geologic analyses and assessment for the Greater Green River Basin in Wyoming.
- Continued efforts in validation of fracture conductivity models for proppant transport.
- Completed tests of the high energy gas frac process through perforated casing.
- Completed coastal sandstone interval stimulation at the multiwell experiment site.

Environmental and Advanced Research
- Completed preliminary mapping of gas hydrate deposits on the Alaskan North Slope.
- Continued site specific geologic evaluations of probable offshore hydrate deposits.
- Established resource potential for deep source gas in target areas along the U.S. west coast.
- Completed field examination of potential deep source gas occurrences at priority sites in western Washington.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Eastern gas shales	$ 938	$ 355	$ -583

The reduction in funding from FY 1986 to FY 1987 reflects the elimination of those research activities performed under industrial contracts. The projects supported in FY 1987 are focused on in-house research.

The fractured Devonian shale formations of the east and midwest represent an in-place resource in excess of 900 TCF. This information was developed in the early years of the programs, when research efforts were directed at determining the geologic character and magnitude of the shale gas resource. Research efforts progressed to detailed reservoir analysis such as the Offset Well Test No. 1 (drilled in an area of established commercial gas production). The Offset Well Test involves the drilling of closely spaced wells to interrogate the reservoir under baseline conditions. From this work evolved a reservoir model quantifying the interrelationship of identified key reservoir parameters. To validate the reservoir model, a contract was awarded in FY 1984 to obtain additional defined information from selected areas (10 wells) and to establish a second Offset Well Test site in an area with no commercial production history but meeting certain geologic criteria determined by the reservoir model. Testing and evaluation at the second Offset Well site should be completed by early in FY 1987 with prior year funding.

Effective stimulation or the ability to predict that a stimulation technique will provide the needed performance remains as the key research need in the program. One concept, developed from recent reservoir studies, is that of a stimulated horizontal borehole. The same studies indicate that we can expect a multi-fold increase in gas recovery over conventionally stimulated vertical wells where typically only 10-25% of the gas in-place is recovered. The concept takes advantage of the natural fracture pattern by directionally drilling a horizontal wellbore perpendicular to the fracture planes, extending several hundreds of feet, and subsequently stimulating the reservoir at selected intervals. Drilling of the directional well will be completed during FY 1986. During drilling, core will be taken to obtain valuable data for reservoir and stimulation models. The state-of-the-technology for directionally drilling the desired wellbores will be ascertained. Gas flow data from the directionally drilled well can be compared directly with that from adjacent, vertically drilled and completed wells. Stimulation of the well was scheduled to take place in FY 1987 under the technology base program. An attempt will be made in FY 1987 under the Cooperative R&D Venture Pool to solicit industry support in conducting the stimulation and analysis of this promising recovery concept. Planned field testing/evaluation of stimulation models which were to have been carried out in a variety of geologic settings at different fracture intensities will be cancelled.

DOE's in-house research efforts will continue in FY 1987 to focus on the development of predictive capability, i.e., stimulation and reservoir modeling, and on the integration of previously derived laboratory and field data to establish guidelines for industry on ways to optimize gas development/production from shale and associated reservoirs. The technical approach, which utilizes case history studies, will be applied systematically to previously ranked areas of shale production potential to investigate the following: the practical aspects of dual completion from shale and associated sandstone and coal reservoirs; and prospects for in-fill drilling in areas of different natural fracture intensity. Successful completion of these efforts should greatly enhance the economics of Devonian shale gas development. In addition, in-house efforts will continue in the gathering of available production data from shale wells. The data will be compiled and loaded onto a production data base system for subsequent use by modelers and industry.

In-house research activities for the Eastern Gas Shales subprogram are assigned to the Morgantown Energy Technology Center.

	FY 1986 Approp.	FY 1987 Request	Net Change
Western tight gas sands	$ 5,393	$ 3,582	$ -1,811

The reduction in funding from FY 1986 to FY 1987 reflects the elimination of those research activities performed under interagency agreements, national laboratories, and universities. The projects supported in FY 1987 are focused on in-house research and continuation of multiwell research activities.

Supporting research in the area of proppants and fluids for effective western gas sands stimulation and laboratory investigations into fracture propogation/communication across and between sand lenses will be terminated. Parallel efforts to provide the geologic backdrop to understand reservoir properties and response to stimuli, for the major basins will also be terminated.

The U.S. has a very large resource of gas held in low permeability sandstone formations. An NPC study estimated the in-place resource for these tight formations at 924 TCF. Of this resource, up to 300 TCF are contained in tight and mostly lenticular gas sands of the Rocky Mountain geologic basins. DOE's program focuses on these tight lenticular formations. Early in the subprogram history, a series of individual massive hydraulic fracturing (MHF) field experiments were performed. The results were very erratic and difficult if not impossible to explain. This led to the concept of the Multi-well Experiment (MWX) which consists of three closely spaced wells (125-150 ft apart) drilled to a depth of 7,500 feet and penetrating many lenticular sandstones. The experiment is designed to investigate the production characteristics of tight lenticular sandstones and to develop the strategies to effectively extract the resource, as well as to develop reservoir and stimulation diagnostics and predictive capability. The program strategy is to study and resolve technical problems at the MWX site, and then extrapolate these results across the Piceance Creek Basin and finally to the other two priority basins (Greater Green River and Uinta). Installation of the MWX facility was completed in FY 1983. A five-year experimental plan was developed to systematically obtain needed information. It is scheduled to end in FY 1988 with expiration of the current lease. During FY 1986, the last in a series of stimulations in the Coastal zone will be completed.

During FY 1987, field experiments will concentrate on the feasibility of stimulating and producing gas from remote sand lenses (not directly intersected by the wellbore). Stimulating and producing from remote sand lenses is the key to economic and efficienct recovery of gas from tight lenticular gas sands.

In FY 1987, in-house research activities will continue. Emphasis will be on the analysis of reservoir, stimulation, and geologic data derived from the multiwell experiment. In-house geoscience studies will contribute knowledge to a better understanding of the various processes affecting gas recovery from lenticular sands. These efforts include log versus core studies (permeability), fluid/rock interactions during stimulation and lineament analysis. Together with selective data from industry test wells in other parts of the Piceance Basin, when available, researchers will attempt to extrapolate MWX results to other areas. Database activities will also continue with the gathering and loading of individual well production data as available from the Piceance and Greater Green River Basins.

In-house research activities for the Western Tight Gas subprogram are assigned to the Morgantown Energy Technology Center.

	FY 1986 Approp.	FY 1987 Request	Net Change
Environmental and advanced research	$ 2,172	$ 1,315	$ -857

The reduction in funding from FY 1986 to FY 1987 reflects the elimination of those research activities performed under industrial contracts, and universities. The projects supported in FY 1987 are focused on in-house research and geophysical/geochemical efforts under interagency agreements.

Workshops were held during FY 1982 for both gas hydrates and deep source gas. The primary purpose of these workshops was to thoroughly review past and ongoing research in these potential resource areas and to serve as a basis for formulating a program of research. From these workshops it became clear that little was known about either gas resource and that little research was being carried out in these areas. It was determined that a systematic and coordinated project was warranted to substantiate the presence, define the reservoir characteristics and develop recovery strategies for both the gas hydrates and deep source gas (specifically the deep source gas associated with subduction of organic materials at tectonic plate margins).

Under certain temperature and pressure regimes, gas in the presence of sufficient moisture will form gas hydrates - gas trapped in an ice crystal matrix (such structures are called clathrates). In addition, gas is also thought, in many situations, to be trapped beneath the main hydrate layer, forming a "free gas" zone. It is theorized that gas hydrates and associated free gas may represent a vast resource in excess of 2,500 TCF. However, little information exists to prove or disprove the theory.

In a coordinated effort with NSF, DOE, in FY 1983, began evaluating natural hydrate core taken during deep drilling operations off the coast of Guatemala. The laboratory program (aided eventually by the use of synthetic gas hydrates) set out to obtain basic chemical, physical, and thermodynamic properties and to evaluate diagnostic techniques that might be used to identify and quantify gas hydrates in situ. A parallel effort was undertaken to create a gas hydrate reservoir model, and using the model, to investigate recovery scenarios (both thermal and depressurization techniques are being examined). Both of these efforts will continue during FY 1987, utilizing in-house research teams. Other in-house activities during FY 1987 include laboratory optical tests, collection and analysis of seismic profiles, and methane displacement analysis. With the knowledge gained thus far from the laboratory work, the first field tests will be conducted in FY 1986 on the North Slope of Alaska to attempt to measure gas hydrates in place using geophysical techniques. The North Slope site was chosen because of the industry drilling data that is available that can be integrated with and help validate the data obtained. A planned second year's effort on the North Slope of Alaska to obtain surface and subsurface geophysical and geochemical measurements of suspected hydrate deposits to further define hydrate target areas and understand hydrate reservoirs will be completed during FY 1987. The Canadian government is interested in gas hydrates both as a potential hazard relative to production operations and as a potential energy source, and a draft MOU has been prepared. Interest on the part of Canada, academia, and industry will be leveraged in an attempt to pursue planned work under cooperative R&D ventures following OMB guidelines.

The deep source gas project seeks to determine whether past subduction of the oceanic plate beneath the continental plate along the U.S. west coast carried sufficient organic material and created sufficient temperature and pressure to generate large volumes of natural gas. Such a determination would impact on where exploration for gas reservoirs would be undertaken. More specifically the program seeks to establish the existence of natural gas arising from these deep source zones, establish migratory paths, determine the existence of potential gas reservoirs, define the limits of the target areas, and quantify the resource. Geological characterization tasks, initiated in FY 1984, were aimed at target definition to provide input towards resource potential and to aid in field verification of the subduction zone concept. Preliminary target areas have been identified (N. Calif., Oregon, W. Washington). These predominantly geophysical and geochemical studies utilizing in-house research teams will continue during FY 1987 to further define these target areas and thus help to determine their gas potential. During FY 1985 a new phase was initiated with the advent of experimental studies of deep gas composition, history of deep gases; and the development of a gas detection/differentiation system. Completion of these efforts will add to our knowledge of deep gas composition, identification of deep gases, and the potential for gas originating and being preserved along and adjacent to subduction zones.

An attempt will be made to solicit the cooperation, through the Cooperative R&D Venture Pool, of industry, universities, institutes and public laboratories in the pursuit of the fundamental research associated with developing a better understanding and therefore determining the development potential of the vast gas hydrate and deep source gas resources.

In-house research activities for gas hydrates and deep source gas are assigned to the Morgantown Energy Technology Center.

FTE Staffing Request

Direct FTE's are funded by this budget activity and include Federal personnel directly engaged in in-house research at the Energy Technology Centers. Although all indirect FTE's are funded in the Program Direction and Management Support budget activity, those who support the planning, management, and contract technical direction functions for this activity are included here in order to provide a clearer indication of the total Federal workforce supporting this activity.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
PROGRAM DIRECTION AND MANAGEMENT SUPPORT
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986[1] Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Program direction and management support (FE)					
Management support:					
Headquarters program direction					
Operating expenses	$ 8,273	$13,380	$13,380	$11,260	$ -2,120
ETC program direction					
Operating expenses	37,907	39,265	39,265	28,740	-10,525
Subtotal	46,180	52,645	52,645	40,000	-12,645
The Federal Inspector for the Alaska Natural Gas Transportation System:					
Operating expenses	...	511[2]	511	221	-290
Subtotal	...	511	511	221	-290
Total					
Operating expenses	46,180	53,156	53,156	40,221	-12,935
Program direction and management support	$46,180	$53,156	$53,156	$40,221	$-12,935
Staffing Total FTE's: Direct ...	0	0	0	0	0
Indirect .	223	249	249	191	-58

1/ Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

2/ This amount represents funding for the Office of the Federal Inspector funds appropriated under the Fossil Energy R&D account in the Department of Energy in FY 1986.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Approp.	General Reduction	Gramm-Rudman-Hollings	Total
Program direction and management support (FE):				
Management support:				
Headquarters program direction				
Operating expenses..........	$14,003	$ -76	$ -547	$13,380
FE program direction				
Operating expenses..........	41,086	-216	-1,605	39,265
Subtotal..............	55,089	-292	-2,152	52,645
Institutional Investment:				
Capital equipment...............	3,000	-18	-117	2,865
Alaska Pipeline Inspector.........	535	- 3	- 21	511
Construction......................	3,485	-16	-137	3,332
Subtotal, Program Direction and Management Support..........	$62,109	$-329	$-2,427	$59,353
General Reduction:				
Operating Expenses..............	-295	-295	-	-
Capital Equipment	- 18	18	-	-
Construction	- 16	16	-	-
Total, General Reduction......	-329	329	-	-
Total Program Direction and Management Support......	$61,780	-	$-2,427	$59,353
Operating.........................	55,329	-	-2,173	53,156
Capital Equipment................	2,982	-	- 117	2,865
Construction......................	3,469	-	- 137	3,332

461

Summary of Changes

FY 1986 Appropriation enacted	$53,156
Program increases and decreases:	
Management Support	
o Headquarters program direction - decrease in funding for salaries and related expenses including SBIR assessment	-2,120
o ETC program direction - decrease in funding for site support and other overhead items	-10,525
Subtotal	-12,645
The Federal Inspector for the Alaska Natural Gas Transportation System	
o Reduce activity of the project sponsors and liaison with other project participants	-290
FY 1987 budget request	$40,221

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Management support	$52,645	$40,000	$-12,645
Headquarters program direction	$13,360	$11,260	$ -2,120

The FY 1987 funding of $11,260,000 for Headquarters program direction includes $7,178,000 for salaries, benefits and travel for 109 FTE's at Headquarters including 35 FTE's associated with general management and program support and 74 FTE's for technical program direction. The FY 1987 employment estimates assume enactment of legislation to reduce or repeal legislative employment requirements. Until the requirements are changed, the Department plans to comply with the legislative requirements regarding personnel levels.

The Headquarters staff is responsible for overall program direction. In carrying out this responsibility, the Headquarters staff: implements DOE policy and communicates that policy to the Energy Technology Centers; sets program objectives; develops program plans and evaluates alternative program strategies; develops and defends budget requests to the Office of Management and Budget and to the Congress; approves procurement plans; and monitors work progress, evaluates projects, and approves revisions in work plans as required to attain program goals.

The proper coordination and direction of the Fossil Energy program requires close and active participation by Federal personnel in contract selection and administration and requires frequent reviews by Headquarters staff with program responsibility. The complexity of the program, the geographic distribution of the research efforts throughout the U.S., and the intensive and frequent reviews necessary to manage these efforts requires constant coordination with performing organizations.

In addition, the FY 1987 request includes $4,082,000 for overhead expenses generic to the entire FE program which were financed in previous years (FY 1985 and prior) by program assessments, including $100,000 for quality assurance activities. These expenses also include printing; historically black colleges; small business innovative research program; and general management support including computer services, technical support services, conferences, etc.

ETC program direction	$39,265	$28,740	$-10,525

The FY 1987 funding of $28,740,000 provides for indirect costs at the Energy Technology Centers (ETC's) in support of day-to-day project management functions for assigned programmatic areas. Indirect costs provide for facility operations, maintenance, finance and administrative support, and other costs not appropriately chargeable to R&D projects. In addition, ETC program direction funds provide for salaries, benefits, and travel for 250 personnel who perform indirect activities that support all Fossil Energy R&D programs. It should, also, be noted that there are 180 direct funded FTE's performing R&D work. Typical work activities performed include contract and National Laboratory monitoring; development and maintenance of project, budget, and procurement plans, and other activities related to program and site support. Funding for the direct costs (personnel and materials) of R&D work performed on-site at the ETC's is included in the various R&D program budget requests. It should be noted that in light of a restructured and reduced Federal research program carried out through the cooperative agreement with NIPER, a Bartlesville Project Office is no longer required. It is anticipated that proposed legislation will be submitted for consideration to authorize the "privitization" of the federally-owned research center located at Bartlesville.

	FY 1986 Approp.	FY 1987 Request	Net Change
The Federal Inspector for the Alaska Natural Gas Transportation System	$ 511	$ 221	$ -290

The Office of the Federal Inspector for the Alaska Natural Gas Transportation System (OFI), authorized by the Alaska Natural Gas Transportation Act of 1976, began operation in July 1979 pursuant to Executive Order No. 12142. The Federal Inspector is responsible for coordinating all Federal activities pertaining to the pipeline in order to assure timely, efficient, safe, and environmentally sound construction.

The current workload of the Federal Inspector requires a small staff (3) and consists of following the reduced activity of the project sponsors and liaison with other project participants. All field activities have been completed and field offices are being deactivated. Beginning in FY 1986, funds for the OFI were appropriated under the Fossil Energy Research and Development account in the Department of Energy for administrative support purposes.

All essential technical work will have been completed by the fall of 1985. The need for technical assistance will be minimal and on a case-by-case basis as environmental/technical issues surface. All field offices will be closed and arrangements maintained to contract for any necessary technical services that might arise.

The primary activities of the OFI will include:

- liaison with the sponsors, producers, other Federal agencies, the State of Alaska, and the Canadian Government;
- the assessment of developments in the world energy market, specifically the U.S. and Canadian oil and gas situation as they affect the Alaska Natural Gas Transportation System (ANGTS). Participation in studies and other activities performed by DOE staff, other Federal agencies, the State of Alaska, or the Canadian government as they pertain to related energy transportation systems;
- participation in Canadian and U.S. regulatory activities that could impact the remobilization of ANGTS;
- participation in additional advance planning for Phase II; and
- performing the routine administrative and management functions of the OFI.

As some of the these functions overlap existing DOE responsibility, the attachment of the OFI to DOE for administrative purposes will benefit both organizations by allowing closer coordination and eliminating duplication of efforts.

The FY 1987 budget request and outyear estimates reflect costs for rent, communications, and related "overhead" costs to be provided by DOE through a Memorandum of Understanding. All other object class estimates flow directly from the total number of workyears projected (3), and are based on average historical costs per workyear.

Construction of the gas pipeline itself is divided into two stages. The first stage, which was completed in the fall of 1982, involved construction of portions of the Eastern and Western Legs (referred to as "prebuild" or "Phase I" construction) to transport natural gas from Alberta, Canada. Phase I required construction of 529 miles of the system in Canada south of James River Station, 823 miles of the Eastern Leg from the U.S.-Canadian border to Ventura, Iowa, and 160 miles of the Pacific Gas Transmission System from Idaho to Stanfield, Oregon. The total 1,512 miles completed to date represents 32 percent of the entire ANGTS system.

The second phase of the projects is the completion of the Alaskan and northern Canadian portions, the Alaska Gas Conditioning Facility (AGCF), and lower 48 segments necessary to deliver the Alaskan natural gas to the continential U.S. As of April 1982, construction of this portion of the system was scheduled to be completed during the winter of 1989-90. While the Northwest Alaskan Pipeline Company (NWA) has not officially announced a new system completion date, the OFI is assuming that the pipeline will be completed sometime in the mid 1990's. The general opinion of the ANGTS participants, gas industry analysts and government regulators is that, within a few years, the gas markets will have stabilized and the financing prospects improved enough to permit the second phase of ANGTS construction to proceed.

Although the OFI foresees some additional delays in the startup of Phase II, the ANGTS project has been brought to a relatively advanced stage of planning, such that it could move forward fairly quickly when market conditions are more appropriate. All major regulatory work has been completed, except for the final FERC certificate and the State of Alaska's Right-of-Way Grant. The basic engineering is nearly to the point of final design, with the solution of the frost heave problem and approval of the Design Criteria Manuals. Given these few additional requirements, the OFI believes that pipeline construction in Alaska could begin about two years after a remobilization takes place.

FTE Staffing Request

Fossil Energy is requesting a total of 542 FTE's. Of this amount, 180 FTE's are directly funded personnel performing hands-on research and are budgeted for in each of the separate activity lead tables and are identified as "direct FTE's". The remaining 362 FTE's are financed in the Program Direction and Management Support activity in FY 1987. Of this amount, 171 FTE's are closely associated with separate program activities and can be identified as indirect FTE's within the individual programs in each separate activity lead table. Of the remaining 191 FTE's, there are 35 FTE's at Headquarters which include the immediate Office of the Assistant Secretary for Fossil Energy and his supporting budget and administrative staff; 153 FTE's support the ETC's policy and management functions and 3 FTE's support the Office of the Federal Inspector for the Alaska Natural Gas Transportation System.

The FTE request described above is summarized as follows:

	Program Direction	Direct	Total
Direct			
METC	0	73	73
PETC	0	107	107
Subtotal	0	180	180
Policy and Management			
HQ	35	0	35
METC	65	0	65
PETC	88	0	88
Alaska Natural Gas Transportation System	3	0	3
Subtotal	191	0	191
Technical Program Direction			
METC	72	0	72
PETC	25	0	25
Headquarters R&D	74	0	74
Subtotal	171	0	171
TOTAL	[illegible]62	180	542

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
PLANT AND CAPITAL EQUIPMENT
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 1/ Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Plant and capital equipment (FE)					
Capital equipment:					
Capital equipment	$ 4,425	$ 2,865	$ 2,865	$ ...	$ -2,865
Subtotal	4,425	2,865	2,865	...	-2,865
Construction:					
SPP at ETC's	2,458	2,855	2,855	...	-2,855
METC waste water treatment fac.	2,458	...	...	...	0
METC administration wing	...	477	477	...	-477
Subtotal	4,916	3,332	3,332	...	-3,332
Total					
Capital equipment	4,425	2,865	2,865	...	-2,865
Construction	4,916	3,332	3,332	...	-3,332
Plant and capital equipment	$ 9,341	$ 6,197	$ 6,197	$ ... 2/	$ -6,197
Staffing Total FTE's: Direct ...	0	0	0	0	0
Indirect .	0	0	0	0	0

1/ Adjustments to the FY 1986 Appropriation are shown on the table on the following page.

2/ Plant and Capital Equipment transferred from the Program Direction and Management Support activity.

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

BEST COPY AVAILABLE

Summary of Changes

FY 1986 Appropriation enacted	$ 6,197
Program increases and decreases:	
Capital Equipment	
o No funds have been requested for capital equipment	-2,065
Construction	
o No funds have been requested for construction	-3,332
FY 1987 budget request	$ ...

Budget Request By Subactivity:	FY 1986 *Approp.*	FY 1987 *Request*	Net *Change*
Capital equipment	$ 2,065	$ ...	$ -2,065

Capital equipment is purchased as needed to replace obsolete equipment so that the Energy Technology Centers (ETC's) and National Laboratories analytical capabilities are constantly being upgraded. New state-of-the-art diagnostic instrumentation improves in-house capabilities. Examples of such equipment are as follows: low energy electron defractor, high pressure calorimeter, calibrated blackbody radiation source, molten caustic reactor, Argon ion laser, and various types of oscilloscopes. No funds have been requested for capital equipment in FY 1987.

	FY 1986 Approp.	FY 1987 Request	Net Change
Construction	$ 3,332	$ ...	$ -3,332

Construction funds provide for general plant projects (GPP) at the Energy Technology Centers when needed, and are dedicated to a number of improvements, alterations and additions at each of the Energy Technology Centers. No funds have been requested for construction in FY 1987.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
COAL
FOSSIL ENERGY RESEARCH AND DEVELOPMENT

(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Cooperative R&D ventures pool (FE)					
Operating expenses	$ ...	$ ...	$ ...	$12,500	$+12,500
Subtotal	...	...	...	12,500	+12,500
Total					
Operating expenses	...	...	...	12,500	+12,500
Cooperative R&D pool	$ ...	$ ...	$ ...	$12,500	$+12,500

Staffing Total FTE's: Direct ...
Indirect .

Authorization: Section 4, P.L. 93-577
Section 301, P.L. 95-91

Summary of Changes

FY 1986 Appropriation enacted .... $ ...

Program increases and decreases:

Cooperative R&D Ventures Pool
o Initiation of cooperative R&D ventures .... +12,500

FY 1987 budget request $12,500

Cooperative R&D ventures pool:

Goals/Objectives:

Applied research and technology development efforts in Fossil Energy should strengthen U.S. technological competitiveness in the world market and achieve advancements in capability to produce energy from domestic resources, when needed, at reasonable costs with acceptable environmental and health and safety consequences.

One of the primary goals of all the applied research areas in FE is to effectively transfer technology from Federal and university laboratories to private industry. The earlier industry is involved, and the more directly that the research agenda is guided by the companies' own economic self-interest, the more effective the transfer is likely to be. A new program will be initiated in 1987, which will be in a sense a "pilot" of a transformation of much of FE's industry-performed research. This funding pool will be used to participate in industry-formed cooperative R&D ventures, as an incentive for companies to take advantage of the Cooperative R&D Act of 1984. Objectives of this new approach will be:

- o Implementation of a process by which industry will join with Government in applied research and development activities that will result in products, processes, and technology that will contribute to achieving the energy and technology goals of the United States.
- o Reduction and/or elimination of those traditional barriers that limit the financial and technical cooperation between the private and public sectors (e.g., patent positions, proprietary rights, anti-trust concerns, etc.).

Intra-industry cooperative ventures are ideally suited to this technology-transfer/proof-of-concept stage of activity. By law, and because of the competitive interests of the companies involved, their activity is restricted to pre-competitive (i.e., not product-specific) research and development. This matches Administration policy of supporting longer-term generic research that benefits the public, but not using tax dollars to subsidize a particular company's development of proprietary products. Support of industry-cooperative R&D allows limited Federal funds to strengthen a whole industry and not just one or a few selected players. This can clearly benefit emerging industries as well as more mature ones.

A cooperative venture's research agenda will be initially set by the industrial partners that form it: when DOE chooses to participate in a given venture, the companies will know that through their own willingness to invest they are having greater influence on the direction of Federal funding spending than they do in contract research. The pooled funding will also provide a greater degree of private cost-sharing for applied R&D, allowing Federal dollars to go further.

This pooling also serves as a risk sharing mechanism and Federal funding contributes to that by being more risk neutral than most private funding sources. If the cooperative venture is defined broadly, with a substantial membership base and level of funding, it can perform or sponsor technology development projects in a number of related areas. This serves to further reduce the risk to the participants, assuring better changes for shared successes that will repay each party's investment.

As a partner in such ventures, DOE will share in both decision-making and (where they exist) royalty profits from patents granted to the cooperative ventures.

The Department will not place tight constraints on the types of cooperative opportunities to be considered, but some characteristics will be considered for all proposals:

- the factor by which Federal funding is being leveraged (in all cases, DOE should be a minority partner -- i.e., Federal funds should comprise less than half of the total funding for the venture);
- the Department's certainty that the support they provide will not be displacing support that would otherwise come from the private sector;
- the degree to which DOE shares in royalties or other profits from the venture, proportionate to its contribution to the venture;
- each partnership must contain at least two companies from the same industry (to ensure that their interest will be in pre-competitive R&D); and
- preference should be given to cooperative ventures formed by companies that have previously proven themselves successful in obtaining and managing co-funding from private sources.

DOE will aggressively seek to identify areas of cooperation by providing the forum for effective industry/industry and industry/government interfacing and through contacts with individual companies to serve as a catalyst/broker in the formulation of joint venture proposals. Incentives, aside from monetary contributions, that might be considered by the DOE as a minority partner include:

- The use of expensive, unique government-owned facilities in addition to monitoring and technology transfer support;
- Interfacing/assisting through U.S. Dept. of Commerce on licenses, and patent rights;
- Serving as a vehicle/entree for tying into research being conducted in other countries; and
- Interfacing/assisting through U.S. Dept. of Justice and U.S. Dept. of Commerce as well as public forums to avoid concerns/issues concerning any appearance of anti-trust activities.

The mechanism for the selection of ventures in which to participate will combine two key elements: (1) nomination of projects by the majority industry partners within the broad areas of research sponsored by the Department in the FE program, but especially in the area of oil, gas, or shale resources and underground coal gasification by any applicable technical route, and (2) comparison, evaluation and selection of the most effective projects using criteria consistent with the objectives of the cooperative project pool (e.g., leverage of Federal funds; creation of new and innovative activities; fostering further opportunities for continued advancement; appropriate and sound business terms for all partners; strengthening of U.S. technological competitiveness; strength and quality of venture organization and goals; and significant opportunities for ultimate return of the taxpayer investment through royalty and other forms of future profit sharing).

It is important that incentives be considered and enhanced over the range of potential projects which might be attractive to potential partners, including industrial concerns, industry associations, government or government/industry combinations in friendly nations that share a need for substitute fuels. Two major program activities anticipated to support these objectives (all of which relate essentially to making the cooperative R&D pool mechanism work as well as possible to create valuable joint venture activities) are (1) discovery and building of the consensus opportunities essential to useful joint ventures, and (2) solicitation, analysis, evaluation and other functions needed to make productive joint ventures occur.

Cooperative ventures undertaken will assure tie-in to any downstream profits resulting from application of developed technology porportionate to the DOE share in the venture.

Budget Request By Subactivity:	FY 1986 Approp.	FY 1987 Request	Net Change
Cooperative R&D ventures pool	$ ...	$12,500	$+12,500

The research and development efforts embodied in this request include recovery of gas from unconventional resources (e.g., eastern gas shales, western gas sands, gas hydrates, Arctic sources, deep sources and coalbed methane); application of advanced concepts to the removal of light oil, heavy oil and tar sands from reservoirs where present methods are uneconomical and/or ineffective; recovery of oil and energy from the Western Tertiary and Eastern Devonian and Mississippian oil shale deposits; recovery of gas from underground coal gasification; and other research and development concerning U.S. deposits of oil, gas and shale brought forth to DOE for consideration under cooperative venture arrangements ultimately to make greater use of these resources.

In FY 1986 and prior years, the Office of Fossil Energy has effectively increased the knowledge base on oil, gas, and shale technologies available to industry by supporting both technology base research and development in these areas and applied research and development which had the purpose of encouraging both evolutionary and innovative process related technology enhancements. Within the structure of this FY 1987 budget, the technology base work planned is outlined on the basis of technology areas and individual program elements. The purpose of this section of the FY 1987 budget is to describe the activity planned to make available Federal support for cooperative R&D with non-Federal entities across the whole field of oil, gas, shale, and underground coal gasification which may appeal sufficiently to private sector organizations to achieve joint venture arrangements in which the Federal Government can constructively participate as a minority partner.

The spectrum of applied research and technology development efforts anticipated in these technology and resource areas range from laboratory/bench scale activities through efforts such as field tests--precursors to actual commercial deployment and cash flow. The scale at which the research is to be conducted is anticipated to be a function of how strong an established technology base exists in the area of interest, but it must be limited to pre-competitive stages of maturity. For example, many of the unconventional gas resources of interest have not been defined well enough to develop recovery strategies with confidence. In these instances, industry and other parties could form a cooperative venture with DOE as a minor partner to develop sufficient data requisit to the next step, i.e., design and test of promising recovery concepts. A joint venture under these circumstances might entail a phased approach with an up front formulation phase and a subsequent concept analysis phase. At the other end of the spectrum, broad based industry support may be generated for pursuit of a fundamental concept for conversion of oil shale based on a strong technology base providing sufficient evidence of significantly improved economics and efficiency to warrant correlated technology development and process testing. Similarly, in the area of underground coal gasification, it is expected that the primary interest expressed will be in modest-scale pre-commercial field tests of the most promising concepts to produce the data necessary to allow the subsequent design and construction of commercial plants for the production of competitively priced medium Btu gas to be used as a chemical feedstock for conversion to any of a suite of product options. Additional interests may be expressed in the use of the technology to address otherwise unattractive coals not currently being produced because of their depth, ash content, thickness, or high sulfur content. Finally, much interest has been expressed by other countries (e.g., Brazil, Spain, and Australia) in the utilization of the UCG technology to satisfy their domestic energy needs. This interest is expected to continue and become more intense in the future. Opportunities may also exist for cooperative ventures among equipment manufacturers in other areas of coal utilization.

Wide opportunity for participation in a cooperative venture will be encouraged by working closely with industry and publically sponsored research organizations such as GRI and non-profit research institutions such as NIPER that already serve as government/industry interfaces. However, the major venture participants will ultimately decide on participants and their roles and the ventures pursued for proposal to DOE for minor limited partnership. Membership criteria or limitations will, of course, also be subject to the guidance set forth in the Cooperative R&D Act of 1984 and subsequent legal interpretations.

Further leveraging of our cooperative agreements with Venezuela, Canada, Brazil, and Mexico will be considered. Common interest in the development of recovery technologies could result in foreign countries becoming significant contributing partners up front and establishment of foreign markets for U.S. technology downstream.

The illustrative examples discussed above reflect the Department's current, best estimate of areas where the private sector is most likely to express interest for joint ventures with DOE. However, it is DOE's intent to impose minimal constraints on potential proposals and to select on the basis of technical and financial merit among all proposals regardless of the specific technical area proposed for further R&D.

Department of Energy
Washington, DC 20585

February 13, 1986

Honorable Don Fuqua
Chairman, Committee on Science
and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

In response to language contained in the House and Senate Reports accompanying the Department of the Interior and Related Agencies Appropriations Act for Fiscal Year 1986, as enacted by Public Law 99-190, and in accordance with Secretary Herrington's October 25, 1985, letter to you, I am pleased to provide our report on future options for the Wilsonville Advanced Coal Liquefaction Research and Development Facility. The reports requested that the Department evaluate the feasibility of testing new processes at that facility.

The enclosed report discusses the options for the future of Wilsonville. It identifies the practicalities, advantages, and disadvantages of each option and outlines the possible program participants and cost-sharing arrangements.

We appreciate your continued interest in our programs.

Sincerely,

Donald L. Bauer

Donald L. Bauer
Acting Assistant Secretary
for Fossil Energy

Enclosure

REPORT ON THE
WILSONVILLE ADVANCED COAL LIQUEFACTION R&D FACILITY

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

JANUARY 29, 1986

REPORT ON THE
WILSONVILLE ADVANCED COAL LIQUEFACTION R&D FACILITY

1.0 INTRODUCTION

In response to the Appropriations Committees in their reports accompanying the Department of the Interior and Related Agencies Appropriations Act for FY 1986, as enacted by P.L. 99-190, the Department of Energy has completed a report concerning the Wilsonville Advanced Coal Liquefaction Research and Development (R&D) Facility. As part of its effort to reduce the deficit, and since substantial testing results are already available and disseminated from prior research and testing at the facility, the Administration did not include funds in its FY 1986 budget for the operation of the Wilsonville facility. However, Congress did provide FY 1986 funds to continue the proof-of-concept testing of advancing coal liquefaction technologies at the facility. Those funds will be used for that testing until approximately March 20, 1986. The remaining FY 1986 funds are being deferred in conjunction with the FY 1987 budget request and proposed for use in financing that request.

---

[1] House Report 99-205, pg. 77: "Prior to completion of planned programs at each facility, which is the end of fiscal year 1986 at Wilsonville and fiscal year 1987 at La Porte, the Department should evaluate the desirability and feasibility of testing new processes at these unique facilities. The Department should report the results of these evaluations for the respective facilities to the Congress in conjunction with the budget submissions for fiscal years 1987 and 1988."

Senate Report 99-141, pg. 77: "Both the Wilsonville and La Porte facilities have the potential to be useful in future testing of several new processes currently being tested at bench scale. The Committee joins the House in asking for an evaluation of the desirability and feasibility of testing new processes at these two facilities."

The Wilsonville Advanced Coal Liquefaction R&D Facility is owned by the Electric Power Research Institute (EPRI) and is located on a site in Wilsonville, Alabama, leased from Southern Company Services (SCS). This facility was originally intended as a private R&D test facility. Funding for the construction of the 6 ton-per-day pilot plant came from the Edison Electric Institute (EEI) and SCS. EPRI assumed EEI's participation in 1973 and has provided all funds for capital improvements and a fraction of the operating costs since 1976. In 1976, DOE, then the Energy Research and Development Administration (ERDA), became a co-sponsor of the project and has provided approximately two-thirds of the funding since that time.

The Wilsonville Advanced Coal Liquefaction R&D Facility has been used in the development of coal liquefaction technologies. Coals from Kentucky, West Virginia, Indiana, Illinois, Utah, and Wyoming have been tested in the facility. The original mission of Wilsonville was to aid in proving the Solvent Refined Coal (SRC) concept. Since 1983, Wilsonville has been used in proof-of-concept experiments associated with the two-stage liquefaction process. The congressional action envisioned that proof-of-concept testing of the close-coupled operation of the two-stage liquefaction (CC-ITSL) system will be conducted in FY 1986, and this will occur until March 20, 1986.

There are a number of options for the Wilsonville Advanced Coal Liquefaction R&D Facility after FY 1986. All of the options except one adversely impact, to some extent, the allocation of available funds to the Department's highest priority activities and are inconsistent with Administration policies regarding industry's technology development with the Nation's goal of reducing the Federal deficit. Details of each option are presented in Section 3.0 of this report.

The Department's 1978 budget request to Congress recommends Option 1 -- no further DOE financial support to the Wilsonville facility after March 20, 1986. This assures that the private sector will provide whatever new funds are necessary for continued R&D activities at the facility.

2.0 WILSONVILLE ADVANCED COAL LIQUEFACTION R&D FACILITY PROGRAM

2.1 General Description of Facility

The Wilsonville Advanced Coal Liquefaction R&D Facility has a nominal capacity of 6 tons of coal per day and contains a coal dissolution reactor (dissolver), a solvent deashing system (Kerr McGee Critical Solvent Deashing Process), and a second-stage reactor for hydrocracking and upgrading the deashed dissolver effluent (ebullated bed catalytic reactor). A new reactor completed in 1985 in close proximity to the catalytic hydrotreater will enable close-coupled operation of the two-stage liquefaction system. Wilsonville also has upgraded and computerized data gathering and analysis capabilities. A detailed process description is contained in the Appendix.

2.2 Summary of Operations

Operation of the Wilsonville Advanced Coal Liquefaction R&D Facility began in 1974 to study the key steps in the SRC process. Based on laboratory experiments, testing of "decoupled" two-stage liquefaction began at Wilsonville in 1981. Very selective production of a low sulfur No. 6 fuel oil substitute was demonstrated using the decoupled two-stage liquefaction configuration, and barrel quantities of liquid products were prepared for small-scale combustion tests. During 1983, the emphasis of Wilsonville activities shifted to the production of higher quality fuel oil and turbine fuels utilizing the ITSL configuration.

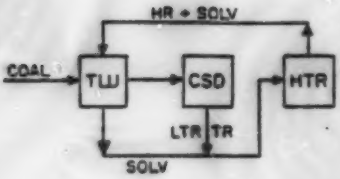
Over the past two years, three modes of ITSL indicated to be promising in bench-scale development work have been tested: Standard ITSL, Double ITSL, and Reconfigured ITSL (shown in Figure 1). Two representative coals were tested during this period: eastern bituminous Illinois No. 6 (Burning Star Mine) and western subbituminous Wyodak (Clovis Point Mine). In addition, three different first stage coal dissolution tests were conducted: short contact time test with the dissolver by-passed; low contact time test with a new downsized dissolver; and mixing test with a modified forced backmixed dissolver. Results generally confirmed bench-scale tests indicating high coal conversion can be obtained at high coal throughputs under properly selected operating conditions. Liquefaction process economics are significantly affected by coal throughput factors. Tracer tests were also conducted that better defined dissolver hydrodynamics and residence times at several different sets of operating conditions. These tests contributed to the developmental activity concerning a comprehensive first stage mathematical model useful in predicting performance at larger scales of technology operation. A new coal slurry drying procedure was also implemented which allowed processing wet as well as predried feed coals.

2.3 FY 1986 Plans

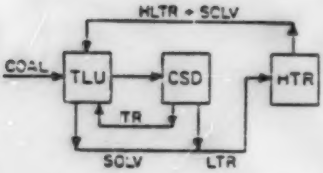
The installation of a new reactor at the Wilsonville Advanced Coal Liquefaction R&D Facility in 1985 enabled close-coupled operation of the two-stage liquefaction system as shown in Figure 2. In response to congressional guidelines, CC-ITSL proof-of-concept testing began at Wilsonville in November 1985.

Within the operating time remaining in fiscal year 1986, one operability/screening run is expected to be completed on Illinois No. 6 coal.

TWO STAGE LIQUEFACTION AT WILSONVILLE -- INTEGRATION MODES TESTED

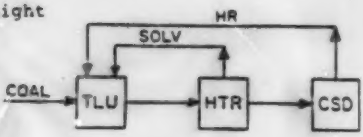

HR + SOLV
COAL
TLU
CSD
HTR
LTR
TR
SOLV

STANDARD
(ITSL)


HLTR + SOLV
COAL
TLU
CSD
HTR
TR
SOLV
LTR

DOUBLE ITSL
(DITSL)

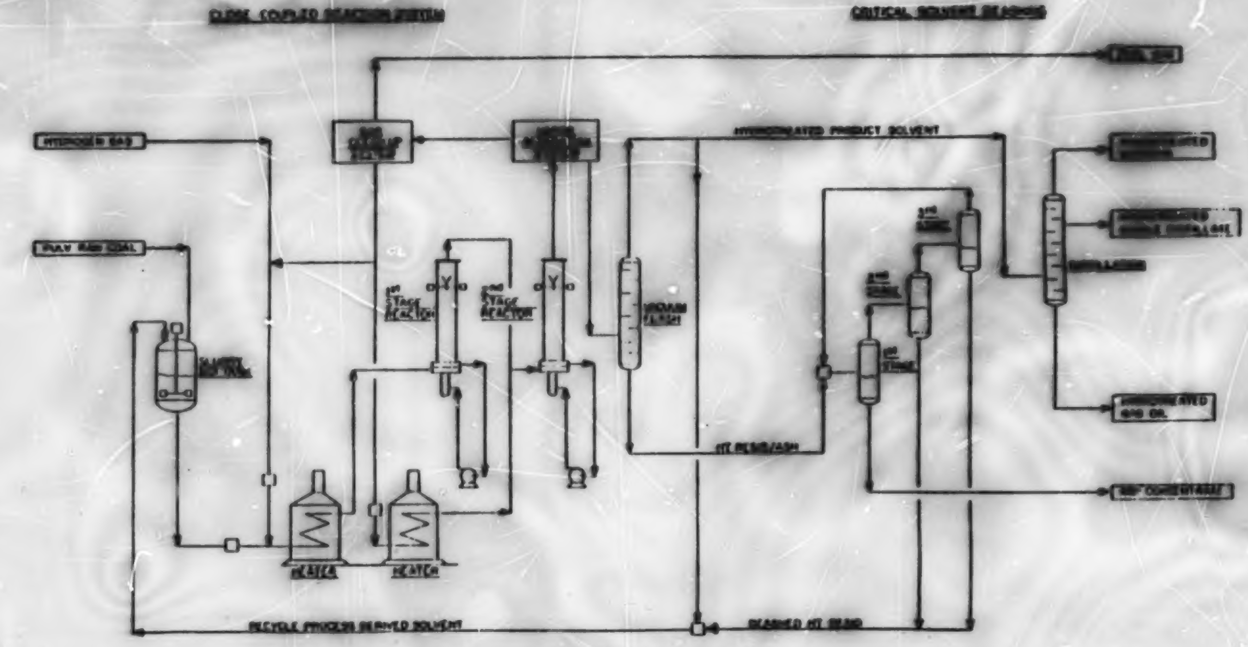
TLU - Thermal Liquefaction Unit
CSD - Critical Solvent Deashing
HTR - Hydrotreater
HR - Hydrotreated Resid
LTR - Light Thermal Resid
TR - Thermal Resid
HLTR - Hydrotreated Light Thermal Resid
SOLV - Solvent


HR
SOLV
COAL
TLU
HTR
CSD

RECONFIGURED ITSL
(RITSL)

FIGURE 1

BEST COPY AVAILABLE


CLOSE COUPLED REACTION SYSTEM
CRITICAL SOLVENT DEASHING
HYDROGEN GAS
PULV RAW COAL
SLURRY MIX TANK
1st STAGE REACTOR
2nd STAGE REACTOR
VACUUM FLASH
HYDROGENATED PRODUCT SOLVENT
HEATER
HEATER
HT RESID/ASH
1st STAGE
2nd STAGE
3rd STAGE
DISTILLATION
HYDROGENATED GAS OIL
RECYCLE PROCESS DERIVED SOLVENT
DEASHED HT RESID

CLOSE COUPLED INTEGRATED TWO STAGE LIQUEFACTION SYSTEM

FIGURE 2

480

3.0 POTENTIAL OPTIONS FOR THE WILSONVILLE ADVANCED COAL LIQUEFACTION R&D FACILITY

Five potential options have been identified for this facility when the preceding activities are completed. All of the options except Option 1 impact adversely to some extent the Nation's goal of combating successfully the Federal deficit (and increasingly so in the higher numbered options). Details of each option are as follows.

3.1 Option 1 - No DOE Financial Support to Wilsonville; Responsibility for the Future, if any, Would be Outside DOE Oversight or Participation

Under this option, DOE would let all financial, policy, and institutional support for the Wilsonville Coal Liquefaction R&D Facility end.

EPRI, as owner of the facility, would be free to use or dispose of the facility in any way it and its industrial members/ partners felt appropriate.

3.2 Option 2 - No DOE Financial Support to Wilsonville, but Establish an Active Policy and Institutional Effort to Create a New Consortium to Provide Funds for Testing at the Facility

Under this option, DOE would withdraw its financial support to the Wilsonville Advanced Coal Liquefaction R&D Facility, but at the same time would establish an active policy and institutional effort to assist EPRI in creating a new consortium to utilize the facility.

The most significant advantage of this option is that it gives EPRI and potential industrial and international partners the most flexibility in deciding the future of Wilsonville. Those partners' decisions would be guided by the outlook for the commercial usefulness of the various technology options over the time period in which they would be developed to commercial readiness.

3.3 Option 3 - Seek New Cooperative R&D Venture in Accordance with Administration Policies on Ventures with No A Priori Decision on Coal Liquefaction Technologies to Undergo Proof-Of-Concept Experiments and With DOE Serving as a Limited Monetary Partner

DOE would investigate, with EPRI, establishing a new program initiative for the Wilsonville Advanced Coal Liquefaction R&D Facility, emphasizing cooperative R&D ventures with industry and/or international participants. Under this initiative, there would be no a priori decision on the coal liquefaction technologies to undergo proof-of-concept experiments. Further, the Wilsonville Advanced Coal Liquefaction R&D Facility could be modified to meet the specific needs and proprietary positions of the partners. Under this option, DOE would encourage the formation of a cooperative R&D venture in accordance with Administration policies on ventures. Such a venture would take advantage of the National Cooperative Research Act of 1984. The approach would have as an objective the implementation of a process by which industry and government will join in applied R&D activities that will result in products, processes, and/or technologies that contribute to achieving the energy and technology goals of the U.S. Further, this approach would lead to a reduction of the traditional barriers that inhibit the financial and technical cooperation between the private and public sectors (e.g., patent positions, proprietary data, anti-trust concern, etc.).

Tight constraints would not be placed on the types of opportunities to be considered for the cooperative R&D ventures, however, several factors would be applied. In all cases, the Federal share of the total venture would be less than half the total funding for the venture. Further, DOE would share in royalties and other profits from the venture, proportionate to its contribution. DOE would only enter into ventures where Federal funding does not displace support which would otherwise come from the private sector.

This option would give the private sector a greater flexibility and role in setting coal liquefaction R&D priorities and thus assure greater relevance to the marketplace. Further, this approach would lead to an increase in non-Federal support for the Wilsonville facility.

3.4 Option 4 - Subject to EPRI Agreement, Modify the Existing Facility to Conduct Proof-of-Concept Experiments on the Co-Processing of Coal with Residual Oil

Under this option, the Wilsonville Advanced Coal Liquefaction R&D Facility would be modified, with EPRI agreement, to incorporate the co-processing initiative. DOE would seek out new participants (both domestic and international) who would be willing to establish an equity position in the project, with the goal of reducing DOE's historical percentage contribution to the project. There would be no a priori agreement between DOE and EPRI as to the co-processing technology which would be tested at Wilsonville as the selection of the specific co-processing project would place considerable emphasis on the equity position taken by the participants.

DOE conducted preliminary feasibility/engineering analyses on the modifications necessary at Wilsonville in order to conduct co-processing proof-of-concept experiments. While specific modifications would depend on the co-processing technology pursued under this option, these analyses indicate that major modifications would not be required; however, installation of additional holding tanks and associated piping would be necessary. The cost of modification is estimated to average $250,000 - $400,000.

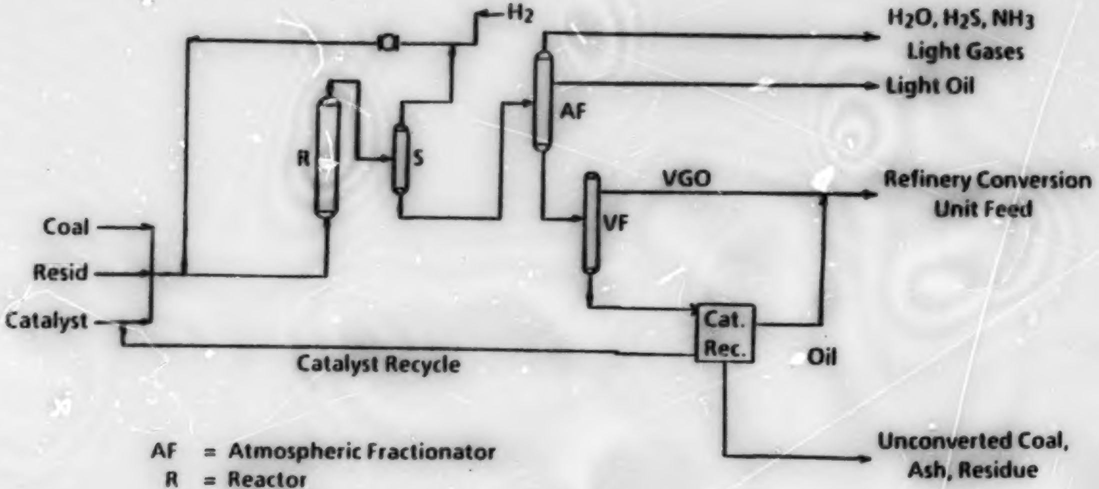
This option would make the facility available to private sector and international participants interested in pursuing co-processing technologies.

3.5 Option 5 - Continue the Existing DOE-EPRI Cooperative Program of Conducting Proof-of-Concept Experiments on Mutually Agreed Upon Technologies or System Configurations

Under this option, the existing DOE-EPRI cooperative program at the Wilsonville Advanced Coal Liquefaction R&D Facility would continue. DOE and EPRI would have to agree on the proof-of-concept experiments to be conducted. These could include confirming the proof-of-concept operability of co-processing of coal with residual petroleum and/or the continued proof-of-concept experiments on CC-ITSL. The Federal share of the cost under this option would be expected to remain approximately 2/3 and the non-Federal share approximately 1/3.

If the existing DOE-EPRI cooperative agreement were continued and/or co-processing chosen for proof-of-concept testing, a number of process candidates exist. DOE is currently supporting two laboratory-scale process development projects. The Universal Oil Products concept (Figure 3) is a single stage process utilizing a recoverable vanadium-based slurry catalyst to convert a mixture of finely ground coal and petroleum resids into distillates. The Lummus process (Figure 4) is a two-stage approach to convert a mixture of hydrotreated petroleum resids and

UNIVERSAL OIL PRODUCTS (UOP) PROPOSED RESID/COAL PROCESSING SCHEME


H2
H2O, H2S, NH3
Light Gases
Light Oil
AF
R
S
VGO
Refinery Conversion Unit Feed
VF
Coal
Resid
Catalyst
Cat. Rec.
Oil
Catalyst Recycle
Unconverted Coal, Ash, Residue

AF = Atmospheric Fractionator
R = Reactor
S = Separator
VF = Vacuum Fractionator

Fig. 3

NO /8290A

SCHEMATIC FLOW DIAGRAM FOR LUMMUS COAL-RESID CO-PROCESSING

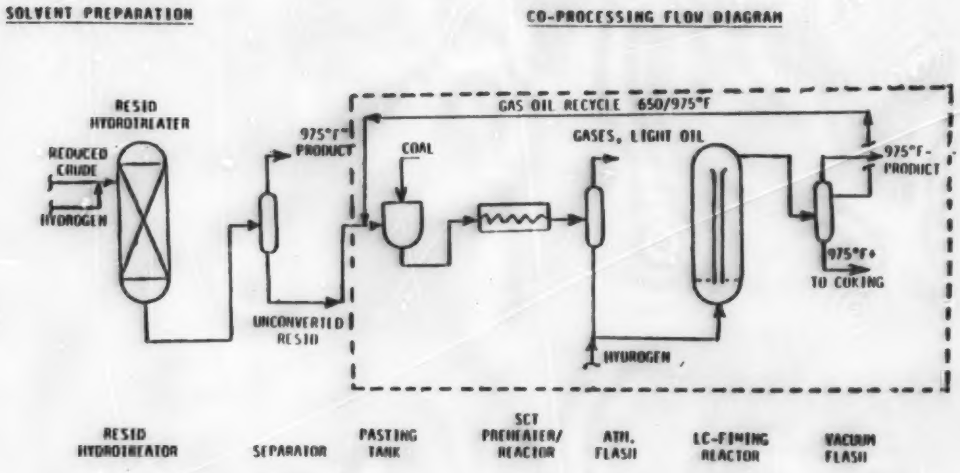

SOLVENT PREPARATION
CO-PROCESSING FLOW DIAGRAM
RESID HYDROTREATER
REDUCED CRUDE
HYDROGEN
975°F- PRODUCT
UNCONVERTED RESID
GAS OIL RECYCLE 650/975°F
COAL
GASES, LIGHT OIL
975°F- PRODUCT
975°F+
TO COKING
HYDROGEN
RESID HYDROTREATOR
SEPARATOR
PASTING TANK
SCT PREHEATER/ REACTOR
ATM. FLASH
LC-FINING REACTOR
VACUUM FLASH

Fig. 4

MO /0293A

coal to a distillate. EPRI, along with the Ohio Department of Energy, Alberta Research Council, and the Ontario/Ohio Synthetic Fuels Corporation, is sponsoring R&D on co-processing at Hydrocarbon Research, Inc.

Preliminary feasibility engineering estimates indicate that the Wilsonville facility possesses capability for testing co-processing concepts without major plant modifications. Additions, such as the installation of additional holding tanks and associated piping, are, however, fully expected to be required.

Evaluation of CC-ITSL, begun in early FY 1986, could continue as an alternative or as an additional testing scheme by sequentially scheduling activities. The objective would include long-term operations to confirm the screening test results developed during FY 1986. Alternative solids separation and other CC-ITSL screening test work would also be completed. Further, testing of lignites and Pittsburgh seam coals could be accomplished if Wilsonville continued operation under this option.

It should be noted that options 3, 4, and 5 provide significant flexibility in selecting proof-of-concept experiments, however, they respectively create an increasingly adverse impact on the Nation's goals of removing the Department from the pilot plant/demonstration phase of technology development which is the proper role of private industry and of combating and reducing the Federal deficit. Co-processing technologies could be tested under each option. The major difference is where the responsibility for the decision on the testing agenda rests. Under option 5, it rests with EPRI and DOE; whereas under options 3 and 4, the decision rests with the partners in the cooperative venture. In option 4, EPRI and DOE will make no a priori decision as to the specific co-processing process(es) to undergo proof-of-concept testing. This constraint is further relaxed under option 3 since there is no a priori decision on the coal liquefaction technologies to be tested.

4.0 COST-SHARING OF WILSONVILLE ADVANCED COAL LIQUEFACTION R&D FACILITY

4.1 Cost of the Wilsonville Advanced Coal Liquefaction R&D Facility

The following table reflects the DOE and private sector investment in Wilsonville to date.

Organization	From	To	Total	Share
DOE	1976	1985	$53,243,000	56.5%
EPRI	1973	1985	32,929,000	34.9%
SCS	1972	1985	5,873,000	6.2%
Amoco	1984	1985	900,000	1.0%
EEI*	1972	1974	945,000	1.0%
Conoco	1977	1977	391,000	0.4%
TOTAL			$94,271,000	100.0%

*Edison Electric Institute (forerunner of EPRI)

Note: Wilsonville facilities were devoted to SRC-I Demonstration Plant technical support work from February 1, 1979 through October 14, 1982.

As an example, the estimated capital and operating costs for Wilsonville for FY 1985 were:

Estimated Expenses	FY 1985
Operating	$ 9,190,000
Capital	1,100,000
Total:	$10,290,000

Note: Capital costs vary significantly from year to year depending on the number and size of capital projects required to carry out the program.

APPENDIX

THE WILSONVILLE ADVANCED COAL LIQUEFACTION R&D FACILITY - PROCESS DESCRIPTION

I. Introduction

Operation of the Wilsonville Advanced Coal Liquefaction R&D facility began in 1974 to study the key steps in the solvent refined coal (SRC) process. Funding for the construction of the 6 ton-per-day pilot plant came from the Edison Electric Institute and Southern Company Services, Inc. Catalytic, Inc. designed, built, and has operated the plant since its inception. The Electric Power Research Institute (EPRI) assumed Edison Electric Institute's participation in the program in 1973 and has provided all funds for capital improvements since 1976. In 1976, the U.S. Department of Energy (DOE), then the Energy Research and Development Administration (ERDA), became a co-sponsor of the project and has provided the majority of operating funds since that time.

The Wilsonville program has achieved four major milestones in the development of its coal liquefaction technology. The conventional mechanical ash separation step was replaced by a continuously operated critical solvent deashing unit in 1978. A state-of-the-art, two-stage biological treatment system installed in 1979 has demonstrated that the wastewaters from a coal liquefaction process can be easily treated to meet or exceed all existing regulatory limits. The addition of a catalytic hydrotreater in 1980 enhanced the flexibility of the R&D facility enabling the investigation of two-stage liquefaction. The completion of a new reactor in 1985 in close proximity to the catalytic hydrotreater will enable close-coupled operation of the two-stage liquefaction system.

II. Process Description - Thermal Liquefaction Unit

The Thermal Liquefaction Unit (TLU) is a direct liquefaction process in which coal, hydrogen and a special solvent are reacted at elevated temperature (750 to 850°F) and pressure (1400 to 2400 psig). This process is similar to other direct liquefaction processes in that the properties of the solvent are very important, but differs from the other processes in one or more of the following areas:

- The principal product is a solid at ambient conditions
- A solid-liquid separation process is required when generating a solid product

Figure 1 is a schematic of the Wilsonville TLU process. In this process, ground coal is mixed with a process-derived solvent and the resulting slurry (up to 40% coal by weight) is pressurized to as high as 2400 psig. Hydrogen gas is added to the slurry and the mixture is then heated to the desired temperature. After heating, the mixture flows to the dissolver, or thermal reactor, where several complex reactions occur. The net products of these reactions are: dissolved Thermal Resid (TR), solvent, light distillates, gases, unreacted coal, and ash (mineral matter). The most desirable products at this point are the TR, distillate, and the excess solvent.

Gases are separated from other products in the high pressure separator and then sent to a gas cleaning system. This system removes hydrogen sulfide and carbon dioxide. A portion of the scrubbed gas is sent to a flare since this is the only method available at Wilsonville for purging the system of light hydrocarbons. The remaining gas is sent to recycle where it is mixed with fresh hydrogen to bring the feed gas purity up to 85% hydrogen by volume.

After an intermediate pressure reduction to about 200 psig, the liquid and solid products are sent to a vacuum distillation column that separates distillable liquid products from non-distillable TR and ash. The distillable products are further separated into solvent, middle distillate, and naphtha. The higher boiling solvent is mixed with ground coal while the lower boiling middle distillate and naphtha are used as fuels. The ash, unreacted coal, and molten TR mixture can be sent to the Kerr-McGee Critical Solvent Deashing (CSD) unit where the ash and unreacted coal are removed, or sent directly to the catalytic hydrotreater for further resid conversion and process solvent hydrogenation.

Until 1978, the ash and unreacted coal were separated from the TR by a batch pressure leaf filter before the products were sent to the vacuum distillation system. Two different filters were tested that produced low ash products, but due to mechanical problems and scale-up consideration, filtration was replaced by critical solvent deashing in July 1978 as the primary method for removing solids from resid.

III. Process Description - Kerr-McGee Critical Solvent Deashing (CSD) Unit

The CSD process is a solid-liquid separation process developed to separate ash and unreacted coal from molten TR. The term "critical solvent" is used to describe this process because extraction of the TR and the separation of the ash and unreacted coal occurs near the critical point of the deashing solvent. (The critical point is a condition of temperature and pressure at which liquid and gas phases become indistinguishable.) The process was developed and financed by the Kerr-McGee Corporation with the objective of licensing the technology.

Figure 2 is a flow diagram of the three stage CSD process. Ash-containing molten resid is mixed with recycled deashing solvent, and the mixture flows to the first-stage settler. Mineral matter and unreacted coal are separated from the TR solution as a heavy fluid phase. This heavy phase is letdown from the bottom of the settler and further processed to recover the contained deashing solvent. The resulting ash concentrate is removed from the solvent separator as a free-flowing powder.

The light phase from the first-stage settler, consisting of TR in deashing solvent, is removed from the top of the settler and heated to reduce the density of the deashing solvent. This decrease in density causes a partial rejection of the soluble coal as a heavy phase. The two phases flow to the second stage settler, where the rejected TR (heavy phase) is withdrawn from the settler and then processed to recover the contained deashing solvent. Product TR is withdrawn from the separator in a molten state (melting point from 300 to 400°F).

The density of the deashing solvent in the light phase from the second-stage settler is further decreased in the third-stage settler, and additional soluble coal is rejected as a heavy fluid phase. The product from the third-stage is called light TR. By adjustment of process conditions in the second-stage settler, the relative quantities of TR and light TR can be varied over a broad range.

The CSD process functions because of the characteristics of the deashing solvent near its critical conditions. The three important characteristics of this solvent are as follows:

- Dissolving power of the solvent changes markedly with temperature in the region near its critical point.
- Dissolving power of the solvent varies roughly as the density of the solvent.
- Dissolving power of the solvent is greater for the "lighter" coal fractions than it is for "heavier" coal fractions.

IV. Process Description - Catalytic Hydrotreater

An "H-Oil" ebullated-bed hydrotreater began operation at Wilsonville in May 1[illegible]. The purpose of the hydrotreater is to catalytically upgrade products from the TLU and/or CSD units.

The technology for design of the hydrotreater was supplied by Hydrocarbon Research, Inc. Figure 3 shows a flow diagram for this unit. A comparison of the hydrotreater and the TLU flow diagrams shows that the processes are similar in many respects. The processes differ principally in the type of reactor. In the hydrotreater, the reactor contains a catalyst that is chosen to selectively remove sulfur or nitrogen and lower the boiling point of high boiling compounds by reaction with hydrogen.

The reactor is called an "ebullated-bed" reactor because a pump is used to recirculate products through the catalyst bed at a velocity sufficient to cause the cylindrical catalyst particles to float or "ebullate" in the upflow stream. A nuclear level gauge is used to detect the catalyst level, while the recirculation rate of the ebullating pump is used to control the catalyst bed height.

An ebullated-bed reactor has the following advantages over a fixed-bed reactor:

- Flow distribution and reactor temperature are more uniform.
- Catalyst can be added to or withdrawn from the reactor during operation because the ebullated-bed has fluid properties.

The ability to add and withdraw catalyst is the most significant advantage because the reactor can be controlled at constant catalyst activity. If deactivated catalyst is not replaced with fresh catalyst periodically, performance of the reactor will decline with time due to catalyst poisoning.

V. Process Configurations

The goal of two-stage coal liquefaction is to make the most effective use of hydrogen consumed by the reactions. Partial attainment of this goal can be achieved through the judicious selection of specific operating conditions such as pressure, temperature, and residence time. Another key variable that will influence hydrogen selectivity and efficiency as well as cost are the many different ways to integrate or configure the TLU unit, Kerr-McGee CSD unit, and catalytic hydrotreater. Figure 4, Two Stage Liquefaction (Non-Integrated Mode), illustrates one way the plant has been configured so that operation of the hydrotreater does not affect the TLU. This configuration is called the non-integrated mode and was used to demonstrate maximized fuel oil production. Figure 5, ITSL (Integrated Two Stage Liquefaction), illustrates the method that was used to fully integrate the units to produce a light, higher quality distillate. Figure 6, Two Stage Liquefaction at Wilsonville - Integration Modes Tested, illustrates four other ways in which the units have been integrated to achieve specific objectives. These various means of integration have demonstrated that a synergism exists between the TLU and hydrotreater units.

New reactor construction is nearing completion which will allow close coupling of the thermal reactor to the catalytic hydrotreater as illustrated in Figure 7. This configuration should permit minimization of capital through the elimination of thermal unit distillate recovery and reduce operating costs through the minimization of retrogressive reactions which occur during further processing of the thermal reactor effluent.

VI. Accomplishments

Operation of the Wilsonville pilot plant since 1974 has contributed significantly to the practical and commercial understanding of direct coal liquefaction. A few of the more important contributions for near-term commercialization are listed below:

- Demonstrated that both filters and the Kerr-McGee CSD process can remove ash and unreacted coal from liquefaction products
- Demonstrated that the CSD process can recover over 90% of the TR fed to the unit
- Proved that up to 90% sulfur removal can be achieved with some coals
- Demonstrated that TR can be produced from bituminous and subbituminous coals
- Developed a method for controlling corrosion caused by chlorine in the feed coal
- Improved mechanical performance of pumps, valves, and compressors by design changes and material selection
- Developed a system for controlling the concentration of coal minerals in the dissolver
- Proved that the process can be operated in solvent balance for extended periods of time
- Developed correlation to relate solvent quality to plant performance
- Demonstrated that the TLU can be operated at temperatures as low as 750°F and still maintain solvent balance, solvent quality, and high TR recovery in the CSD unit (non-integrated mode)
- Demonstrated operation of a state-of-the-art wastewater treatment system
- Demonstrated good material balance closures with highly sophisticated elementally balanced material balances
- Demonstrated 90% or better on-stream efficiency for each unit and all units collectively

- Demonstrated the potential for the elimination of the ash separation step in direct liquefaction using subbituminous coal
- Demonstrated that two-stage liquefaction can convert approximately 50% of subbituminous coal to low nitrogen distillate fuels
- Demonstrated that two-stage liquefaction can convert more than 60% of bituminous coals to low nitrogen distillate fuels
- Developed a mathematical model to predict residual coal conversion in the second (catalytic) stage of two-stage liquefaction
- Developed baseline data for catalytically hydrotreating first stage (thermal) product prior to deashing
- Demonstrated "steady state" integrated two-stage liquefaction of bituminous coal through maintenance of constant catalyst activity by periodic catalyst additions and withdrawals
- Characterized hydrodynamic behavior of TLU reactor by performing radioactive tracer studies
- Produced products from coal with carcinogenicity, mutagenicity and toxicity properties approaching petroleum products

WILSONVILLE THERMAL LIQUEFACTION UNIT FLOW DIAGRAM

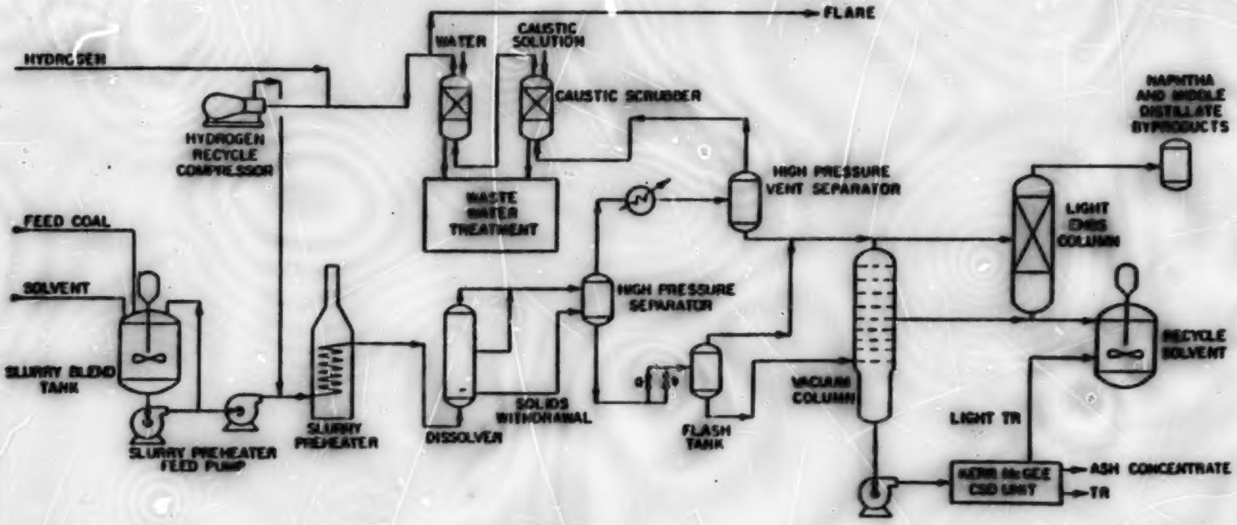

FLARE
HYDROGEN
WATER
CAUSTIC SOLUTION
CAUSTIC SCRUBBER
HYDROGEN RECYCLE COMPRESSOR
WASTE WATER TREATMENT
HIGH PRESSURE VENT SEPARATOR
NAPHTHA AND MIDDLE DISTILLATE BYPRODUCTS
LIGHT ENDS COLUMN
FEED COAL
SOLVENT
HIGH PRESSURE SEPARATOR
RECYCLE SOLVENT
SLURRY BLEND TANK
SOLIDS WITHDRAWAL
VACUUM COLUMN
SLURRY PREHEATER FEED PUMP
SLURRY PREHEATER
DISSOLVER
FLASH TANK
LIGHT TR
KERR McGEE CSD UNIT
ASH CONCENTRATE
TR

FIGURE 1

BLANK PAGE

BLANK PAGE

BLANK PAGE

KERR-MCGEE CRITICAL SOLVENT DEASHING UNIT
FLOW DIAGRAM

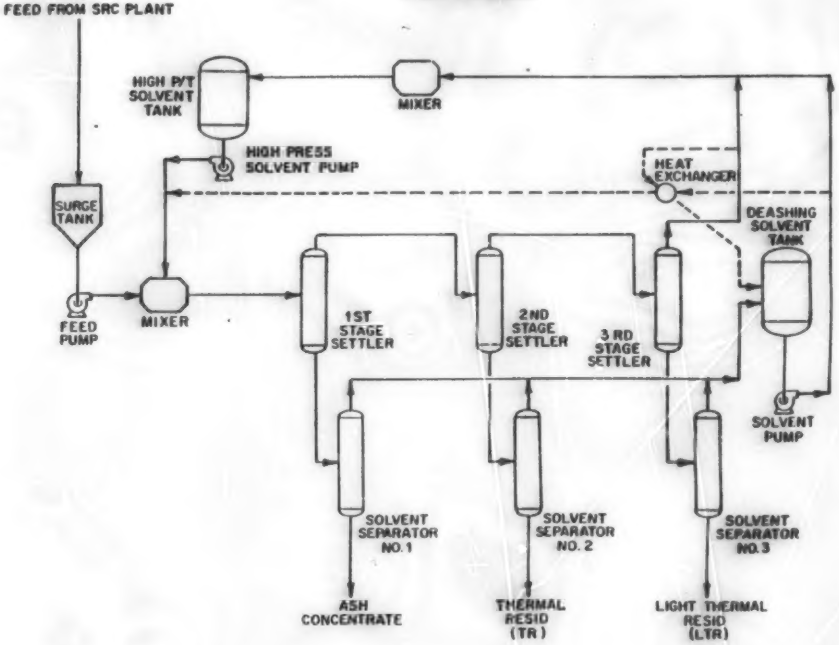

FEED FROM SRC PLANT
HIGH P/T SOLVENT TANK
MIXER
HIGH PRESS SOLVENT PUMP
HEAT EXCHANGER
SURGE TANK
DEASHING SOLVENT TANK
FEED PUMP
MIXER
1ST STAGE SETTLER
2ND STAGE SETTLER
3 RD STAGE SETTLER
SOLVENT PUMP
SOLVENT SEPARATOR NO. 1
SOLVENT SEPARATOR NO. 2
SOLVENT SEPARATOR NO. 3
ASH CONCENTRATE
THERMAL RESID (TR)
LIGHT THERMAL RESID (LTR)

FIGURE 2

H-OIL EBULLATED-BED HYDROTREATER FLOW DIAGRAM

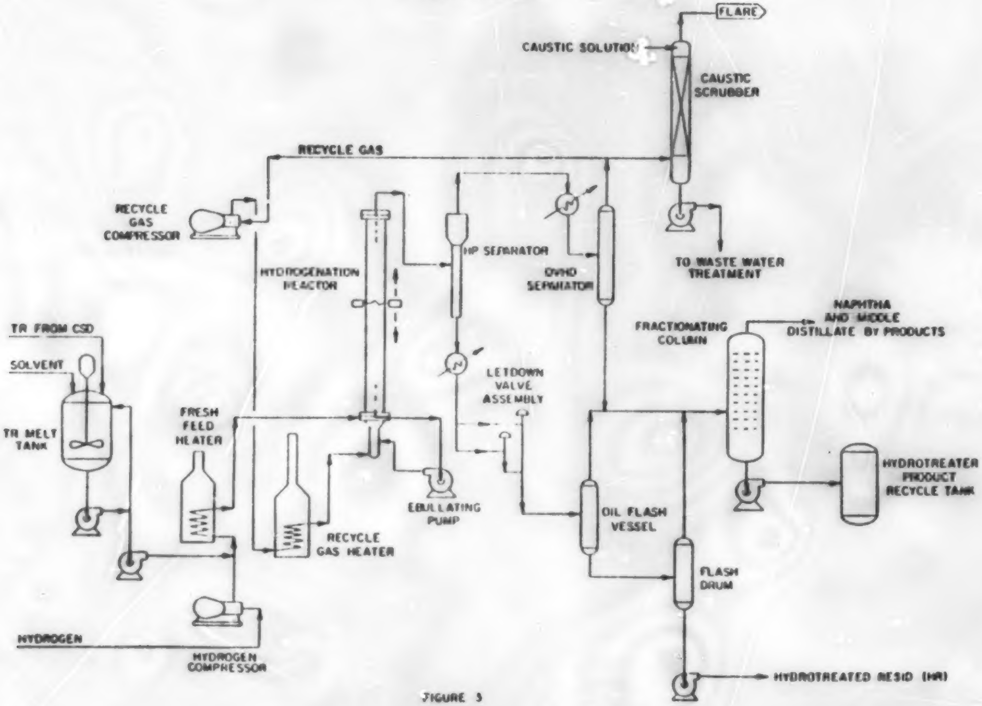
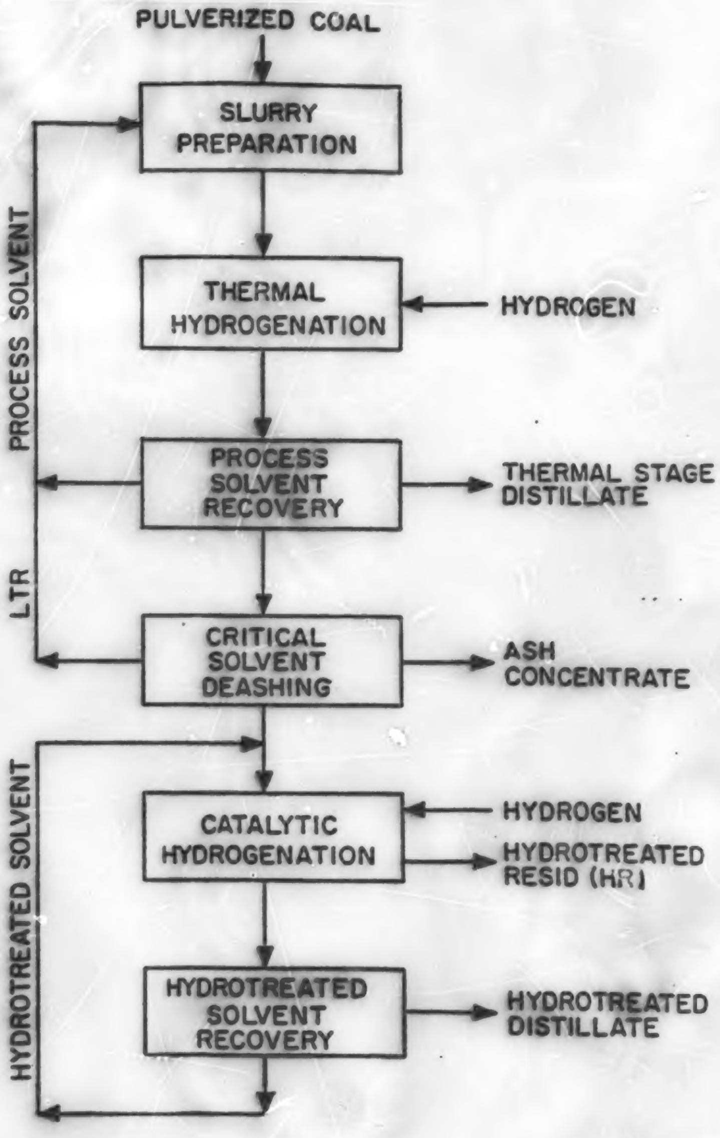
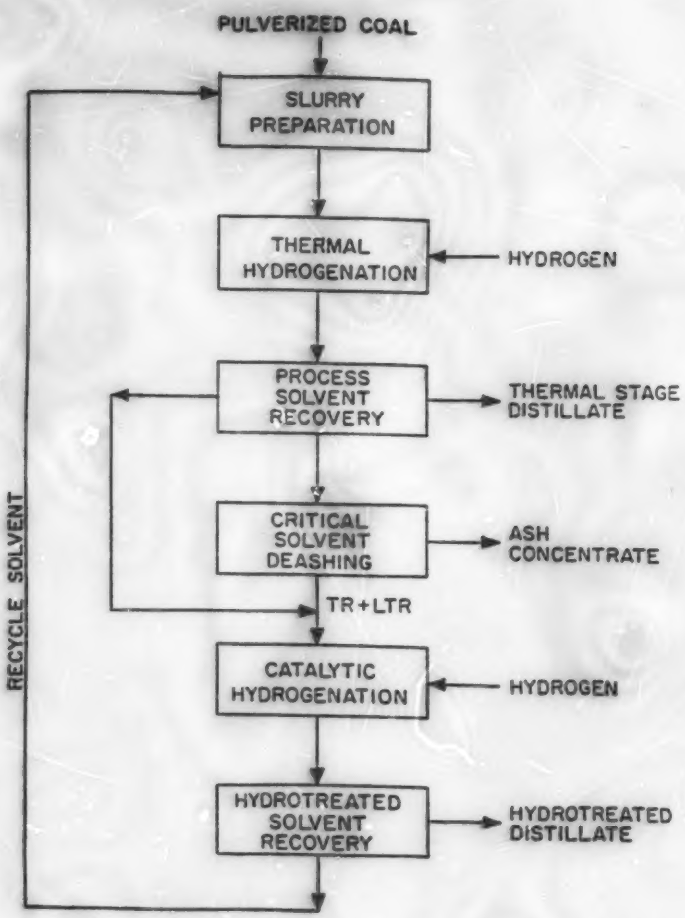

FLARE
CAUSTIC SOLUTION
CAUSTIC SCRUBBER
RECYCLE GAS
RECYCLE GAS COMPRESSOR
HYDROGENATION REACTOR
HP SEPARATOR
OVHD SEPARATOR
TO WASTE WATER TREATMENT
NAPHTHA AND MIDDLE DISTILLATE BY PRODUCTS
FRACTIONATING COLUMN
TR FROM CSD
SOLVENT
TR MELT TANK
LETDOWN VALVE ASSEMBLY
FRESH FEED HEATER
EBULLATING PUMP
OIL FLASH VESSEL
HYDROTREATER PRODUCT RECYCLE TANK
RECYCLE GAS HEATER
FLASH DRUM
HYDROGEN
HYDROGEN COMPRESSOR
HYDROTREATED RESID (HR)

FIGURE 5

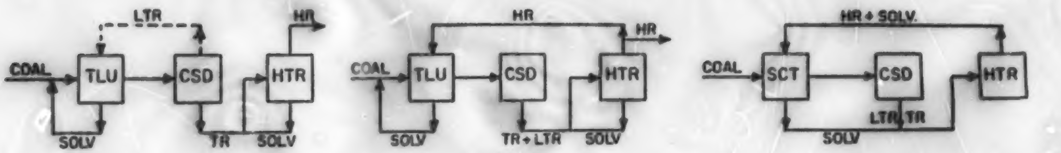

PULVERIZED COAL
SLURRY PREPARATION
THERMAL HYDROGENATION
HYDROGEN
PROCESS SOLVENT
PROCESS SOLVENT RECOVERY
THERMAL STAGE DISTILLATE
LTR
CRITICAL SOLVENT DEASHING
ASH CONCENTRATE
HYDROTREATED SOLVENT
CATALYTIC HYDROGENATION
HYDROGEN
HYDROTREATED RESID (HR)
HYDROTREATED SOLVENT RECOVERY
HYDROTREATED DISTILLATE

TWO STAGE LIQUEFACTION
(NON-INTEGRATED MODE)


PULVERIZED COAL
SLURRY PREPARATION
THERMAL HYDROGENATION
HYDROGEN
PROCESS SOLVENT RECOVERY
THERMAL STAGE DISTILLATE
CRITICAL SOLVENT DEASHING
ASH CONCENTRATE
TR+LTR
CATALYTIC HYDROGENATION
HYDROGEN
HYDROTREATED SOLVENT RECOVERY
HYDROTREATED DISTILLATE
RECYCLE SOLVENT

ITSL (INTEGRATED TWO-STAGE LIQUEFACTION)

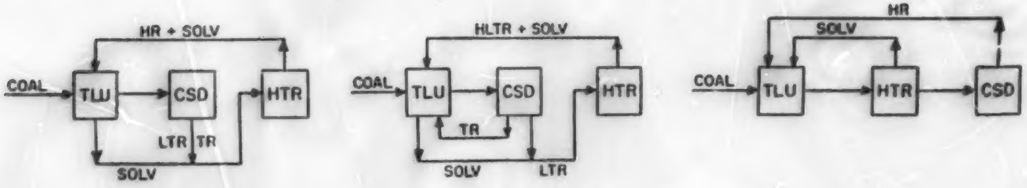
TWO STAGE LIQUEFACTION AT WILSONVILLE - INTEGRATION MODES TESTED


LTR
HR
COAL
TLU
CSD
HTR
SOLV
TR
SOLV
HR
HR
COAL
TLU
CSD
HTR
SOLV
TR + LTR
SOLV
HR + SOLV.
COAL
SCT
CSD
HTR
LTR
TR
SOLV

NTSL (W/WO LTR)-DTSL
(RUNS: 228-236, 240-241)

PITSL
(RUNS: 238-239)

SCT - ITSL
(RUN: 242)

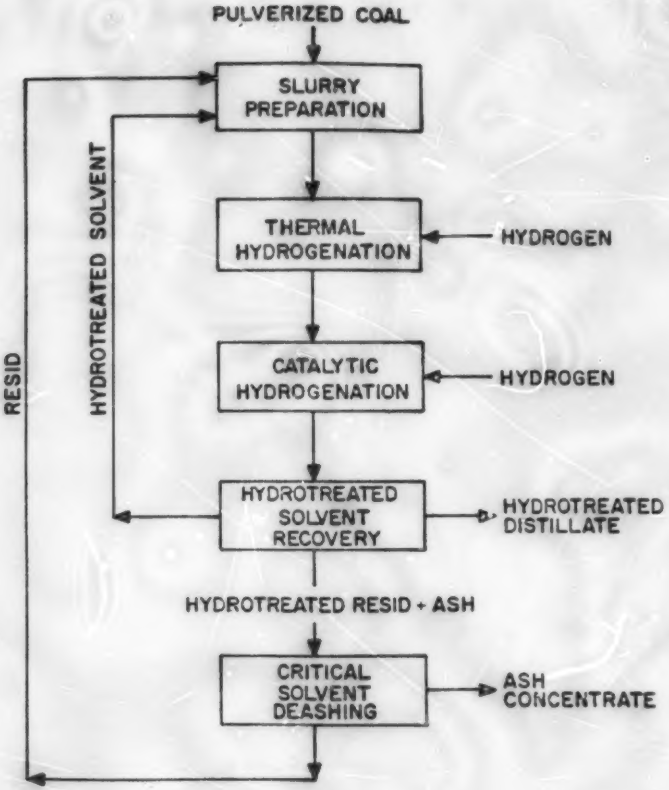

HR + SOLV
COAL
TLU
CSD
HTR
LTR
TR
SOLV
HLTR + SOLV
COAL
TLU
CSD
HTR
TR
SOLV
LTR
HR
SOLV
COAL
TLU
HTR
CSD

ITSL
(RUNS: 243-1,2, 244, 245, 246)

DITSL
(RUN: 246)

RITSL
(RUN: 247)

Figure 6


PULVERIZED COAL
SLURRY PREPARATION
THERMAL HYDROGENATION
HYDROGEN
CATALYTIC HYDROGENATION
HYDROGEN
HYDROTREATED SOLVENT RECOVERY
HYDROTREATED DISTILLATE
HYDROTREATED RESID + ASH
CRITICAL SOLVENT DEASHING
ASH CONCENTRATE
RESID
HYDROTREATED SOLVENT

CCITSL
CLOSE COUPLED INTERGRATED TWO-STAGE LIQUEFACTION

FIGURE 7